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Q&A

Dennis Berardi

INTERVIEW BY JOE FORDHAM

Just north of Lake Ontario, a mysterious silhouetted figure known as Mr. X marks the point of origin for a profusion of visual effects projects that have unleashed hordes of werewolves, zombies, assassins and ping-pong champions into theaters worldwide. World War II-era Shanghai recently took shape here for director Ang Lee's controversial drama, *Lust, Caution*, as did imagery for David Cronenberg's new thriller, *Eastern Promises*. Both represent the latest in a flurry of projects that Mr. X president and visual effects supervisor Dennis Berardi has ushered into his studio, building on relationships forged with filmmakers over 15 years in the visual effects industry.

A Toronto native, Berardi began his career in the early 1980s, after majoring in computer science and economics. "I've always been a bit of a technology buff and a huge fan of film," remarked Berardi. "My first gig out of university was installing computer software and film scanners at the National Film Board of Canada just as things were starting to go digital. It was my first exposure to early 2D digital ink-and-paint and the beginnings of 3D in motion pictures. I fell in love with the emerging digital imaging trend because it represented a great hybrid between creative and technical disciplines."



Berardi went on to run 16mm black-and-white film processors for photochemical optical effects at DSC Laboratories, in Mississauga, Ontario, and then returned to Toronto to spend five years working as a digital film recordist at Cine-Byte Imaging. He earned his first stripes as visual effects supervisor at Command Post Toybox, a digital production company. His experience at Toybox — on titles including *Bride of Chucky*, *eXistenZ*, *Fight Club* and *The Cell* — led Berardi to strike out on his own with Mr. X and, in the last six years, the company has generated visual effects for 46 features. The independence afforded Berardi a long sought-after foothold as producer on the Lions Gate werewolf drama *Skinwalkers*. While gearing up for a new rake of projects, Berardi took time to reflect on his career in the Canadian visual effects and filmmaking communities, as seen from both sides of the trenches.

You started in the technical side of the visual effects industry. How valuable were those experiences for you in terms of the way you approach visual effects today?

It's been ten years since I've done very technical stuff, as I've moved more to the production side and supervising on-set, but my technical experience has served me well. The practical training that I had early on in my career — aerial image compositing, using a flatbed camera stand to photograph an image, or hand-painting a matte — was invaluable, as well. I am still surprised that some of the kids coming out of school today don't have an understanding of the traditional side of the equation, holding a piece of film in your hand and understanding how an exposure works.

What was the visual effects community like in Toronto when you made the move to visual effects at Command Post Toybox?

It was a fun time. A lot of films were shooting around town, and there weren't many visual effects studios. Command Post was mainly a commercials company servicing the New York market, and they wanted to start a feature film visual effects division. I wanted to pursue more creative endeavors, so I came in as a department manager to help get them started.

How did you make the transition to becoming a visual effects supervisor for the first time on *Bride of Chucky*?

At that time, we had a lot of small-scale movies coming up to Canada for economy. When Universal came to town with *Bride of Chucky* — a lower-budget film, around \$20 million, with 50 or 60 visual effect shots — we pitched ourselves as a full-service package: doing all the on-set work and supervising the effects. We met with the filmmakers and did a test where the little puppet threw a CG animated knife across the room. They liked our work; and so we ended up doing all the work on set, and then I supervised the team at Toybox.

When you made the leap into starting your own company, was there an initial project that launched Mr. X?

No, there wasn't. My wife thought I was crazy! Seemingly, our star was rising at Toybox. But I had a dream and a gut feeling that I had to have my own studio. I wanted to engage with filmmakers at a higher level, and I felt that if I was ever going to do that, I needed to be in my own place. It took about six months of covert planning — the company is called 'Mr. X' because it was a surprise to everyone that I was starting it. While I was working on *Jason X*, I found financing, gathered a team and put myself in a position to go live with Mr. X on January 15, 2001, with a team of eight. I sank my own money into the company in partnership with a longstanding Toronto animation company, Topix, co-owned by one of my best friends, Sylvain Taillon. I own 50 percent of Mr. X and Topix owns 50 percent.

What was the competition like in the visual effects industry in Toronto as you were starting out?

There were a lot of companies, and we were starting to see growth of the freelance market, as well. The average price for a workstation was going down and there was a movement away from big SGI hardware to PC- or Macintosh-based workstations, which meant we could put in another desktop for under \$10,000.

What were your company goals at the beginning? How did you intend to distinguish yourself from all those other rising companies and freelancers?

One of our clear goals was to do feature film visual effects. We were filmmakers at heart and we stuck to that. But in the first six or eight months, we couldn't get arrested! The turning point came when we landed a film called *Blizzard*. It was a 300-shot visual effects movie, a Christmas fantasy for Ralph Winter, the producer behind the *X-Men* and *Fantastic Four* movies.

It was a U.K.-Canadian-American co-production with a relatively small budget, but it was a big visual effects commitment for us: \$2 million for about 300 visual effects shots, including reindeer that had to talk and fly. We did a fully animated reindeer test in two weeks, modeled and textured without fur, just to show how the reindeer could fly. They awarded the job to us on the spot, and that was the scariest moment of my life! All of a sudden we were like the dog that caught the bus — you pray that they don't slam on the brakes!

How did you handle 300 shots with such a small crew?

We delivered by taking the company from 12 staff members to just shy of 40 staff members. To service the show, we brought on some heavy-hitters who could code and program, bulked up the 3D department, and created a matchmove department and mini art department. It was a lot harder expanding from 12 to 40 staff members than to expand incrementally to 75, which is our current size.

You've now worked on many films and built relationships with several filmmakers. How did that lead to your producer credit on *Skinwalkers*?

Skinwalkers was the culmination of a dream at Mr. X. We decided that if we remained as one of the commodity-based vendors, beating our brains out competing with each other, we'd be sunk. We wanted to move upstream. While I was making *Jason X*, I started talking with the director, my good friend Jim Isaac. We had worked together previously on a film called *eXistenZ* for David Cronenberg. Jim had this script he liked called *Skinwalkers*, but his production deal had fallen through, so he asked if I was interested in producing it with him. We formed our own company called Red Moon Films, and we started shopping *Skinwalkers* around.

How did you get the project off the ground?

I was working on *Wrong Turn* with Stan Winston and producer Robert Kulzer. I discovered Stan had previously passed on *Skinwalkers*. We pitched it to Robert; Robert passed. We delivered effects on *Wrong Turn*, and they were happy with our work. Robert came back to us with *Resident Evil: Apocalypse*. Mr. X did 250 shots for that. We approached Robert again with *Skinwalkers*, and this time he was interested. He brought on some experienced producers, Lions Gate and Constantin Film



Visual effects supervisor Dennis Berardi has overseen more than three dozen projects at his Canadian visual effects studio, Mr. X. A Toronto native, Berardi progressed from working in photochemical optical effects and digital film recording to serving as visual effects supervisor at Command Post Toybox, and then opened his own company in 2001. One of Mr. X's early milestones was director Zack Snyder's *Dawn of the Dead*. In one climactic scene, Mr. X used combinations of greenscreen elements and artificial intelligence digital crowd simulations to create a sea of zombie aggressors.

came on board, and all of a sudden I was producing, Jim was directing, Stan Winston was doing creature effects, and we were making our movie! We couldn't believe it!

Can you explain the approach you took to creating the werewolves for your film?



*Mr. X has provided visual effects for several Focus Features projects, including director Ang Lee's *Lust, Caution*. The film called for low-key, but historically accurate re-creations of 1940s Shanghai. Mr. X visual effects supervisor Brendan Taylor accompanied the shoot in China and Malaysia, and worked closely with Lee's director of photography, Rodrigo Prieto, to capture the lighting of environments on set. The film's historical advisor guided the search for period buildings on location, which Taylor recorded as high dynamic range images used for digital environment enhancements.*



For a wide view of Wan Chai Harbor, Hong Kong, the production shot a plate in Ipoh, Malaysia. Researching archival photographs of 1930s Hong Kong, Mr. X disguised existing modern architecture by extending period-appropriate buildings and eliminating contemporary road markings. Brendan Taylor filmed greenscreen elements of period signage, streetlamps, pedestrians and handcarts. Mr. X matte painter Matt Schofield and lighting supervisor Wojciek Zielinski then digitally generated harbor frontage and ships' masts across from the buildings.

We wanted to leverage the Stan Winston name and legacy in the industry, and we wanted our werewolf to be really striking — so we had Stan drive the design, even though we weren't sure how much was going to be digital and how much was going to be practical. In our first production

meeting, Stan came up with a really cool design of our lead character, Varek, standing upright in a leather jacket, fully clothed, in the tradition of the classic Universal werewolf. We took that to the next level. We wanted to use guys with appliances on their faces and retain the original actors' eyes so they could still emote, and then we augmented their faces digitally.

How much did you augment?

Every time we had a closeup of a werewolf we separated and rotated the eyes about 15 degrees, and made them bigger. We used warping techniques; and if the warping broke, or had weird seams or pinching, we tracked in digital appliances above the brow that gave the werewolf a very severe look. For wide shots where the werewolves were pretty small on screen, fighting or performing dangerous stunts, they were all CG.

You used digital appliances to great effect in your work with David Cronenberg, particularly in some brutal scenes in *A History of Violence*. What did you do for him on his most recent project, *Eastern Promises*?

David asked us to tweak a couple of gore effects. We had a moment where Viggo Mortensen's character brutally killed a guy in a brawl. We did a digital knife extension and planted the knife into a guy's eye — classic Cronenberg! There were only 46 visual effects, so Aaron Weintraub, our in-house visual effects supervisor, did not need to go on location to London. The big sequence for us involved a servo-controlled animatronic baby puppeteered on set. David asked us to enhance the baby puppet in a scene where it had just been born, moments after being delivered from a C-section.

Was it as extensive as the digital baby work in *Children of Men*?

The scene was mostly working, practically; we just added the last 15 percent to the effect to make it more believable on the big screen. We did some warping effects in three shots. David felt the puppet's movements were a little linear, so we added movement around the brow, and around the eyes and mouth. We flared the nostrils subtly, gave it a little movement on the fingers. David directed all of the action in the warping. We also did a little paintwork on the skin to take the 'curse' off the silicone latex feel.

Another film that must have been quite a coup for you recently was working with Ang Lee on *Lust, Caution*.

Lust, Caution came out of our ability to successfully deliver effects for Focus Features, who have become one of our biggest clients. We were re-creating 1940s Shanghai, but we approached it more as a 3D job than a matte painting job. We used paintings for distant elements; but anything that was midground, or background that had parallax, we created in 3D. Brendan Taylor was our visual effects supervisor. He established a wonderful rapport with Ang's director of photography, Rodrigo Prieto, on set with them in China and Malaysia, as well as at Shanghai Film Studios. It was a long shoot.

What were Brendan's duties on set?

He flew out on stints, 10 or 15 days at a time, gathering data, shooting high dynamic range images for every setup where we were adding significant environment enhancements. We also had to do a lot of crowd replication and augmentation, tiling plates. Brendan's main job on set was to survey

the environment, making sure that we were capturing Rodrigo's lighting. He shot thousands of digital photos of period buildings as textures for our 3D photo-library of Shanghai. Our lighting supervisor was Wojciek Zielinski, and Matt Schofield was our lead matte painter. It was quite an effort, 90 shots in total; and some of the bigger shots, particularly the Nanking Road sequence near the end of the movie, were huge, with giant bluescreen setups on the street.

For your next assignment, you are reuniting with director Paul Anderson and producer Jeremy Bolt. What can you tell us about their remake of Roger Corman's *Death Race 2000*?

Death Race is going to be exciting. We are shooting in Montreal, doing crowds, environments, cars and digital doubles in what amounts to 310 shots — about 40 minutes of the film. Paul wants to make the action really gritty, like *Black Hawk Down*, with cameras inside cars as the drivers take a hit. It's pretty down and dirty. The production has taken over an old train-manufacturing factory that they are converting to a prison with the racetrack surrounding this huge, industrial-looking *Death Race* facility. It's going to be a big job for us from a pipeline point of view because we are at the limits of our rendering abilities again. But that's what we thrive on. Survival in this business is riding the edge, and this show is going to push us to the limits.

It sounds like business is still booming.

Business is going well, but we've seen a polarization of companies. Facilities have either grown very big, offering economies of scale, packaging multiple pictures; or they've gotten really small, cutting the overhead, expanding in the short-term. I can tell you it's not the heyday for a mid-sized company, and Mr. X is in that realm. It's tough. Our sweet spot has always been the movie that wants to look big in texture, tone and feel, but maybe doesn't have an unlimited budget. We are the guys to come to for solutions that explore a hybrid approach. That has become our niche.

As someone who has carved a niche in Toronto, what do you think has given Canada the edge over its counterparts in other territories? Is it really as simple as juggling the exchange rate, as we so often hear?

The exchange rate between Canada and the United States has helped us in the past, but it is almost at par now, with the weakening of the American dollar. The tax credit scheme has been helpful, too, but Australia, Eastern Europe and parts of the States have similar or better film production incentives. Shooting in Toronto does have its advantages, though, because it has a pedigree of filmmaking. We have a 30- or 40-year history of making high-level movies. We've established talent, unions and facilities. You can shoot in the streets, with pretty reasonable stage space and high-level companies who know filmmaking. That is not always the case in other locales.

What's in the future for Mr. X, in the long term?

We're hoping to get another movie off the ground as co-producer. We have three or four scripts that we are starting to shop around. They are genre based, or visually-oriented projects. When I started Mr. X, the majority of movies — blockbusters aside — had an average digital component that comprised less than five percent of the budget. These days, the average



film spends maybe 10 to 15 percent of the budget on digital imaging, or visual effects. So it's a no-brainer for us to leverage our assets. We are also trying to work on our internal pipeline. One of the big pitfalls that happens with companies as they grow is the infrastructure has to be continually re-invented, and it becomes a challenge to stay efficient as the jobs get bigger.

How about the future for you, personally? Can you foresee yourself becoming more involved as a producer and less involved in visual effects?

That is the reason I started moving into producing. Mr. X has been a vehicle to get there, and it has been great fun along the way. The idea is that Mr. X will become a self-sustaining entity, and maybe some of our own productions can fill the pipeline. We are here for the long term. We are trying to establish a legacy. This is my life's work, and I am not going anywhere.

Berardi formed a partnership with director James Isaac and became a producer as well as visual effects supervisor for the Lions Gate werewolf fantasy Skinwalkers. Mr. X designed custom feather shaders and digital feather simulations for an animated hawk, and collaborated with creature effects designer Stan Winston to create werewolf characters and transformations that combined practical and digital effects. The film marked the first in what Berardi hopes will be a continuing development of features designed to leverage Mr.X's position as an independent entity in the burgeoning Canadian film industry.

Overview

Everett Burrell & Greg Nicotero on *The Mist*

Article by Joe Fordham

Back in the first decade of Stephen King's remarkably prolific career, the author produced a 133-page novella inspired by a daydream while on a grocery errand. The story — about a father and his young son trapped in a supermarket by a mysterious mist containing creatures from another world — found its way to print in King's 1985 short story collection, *Skeleton Crew*, and soon became a focus of Hollywood's attention.

Adapted by Frank Darabont, *The Mist* became a hot-ticket screenplay in the creature effects industry in 1988. The project was conceived as an effects-filled studio production, and crossed the paths of creature effects designer Gregory Nicotero at the newly formed KNB EFX Group and makeup effects supervisor Everett Burrell at Optic Nerve Studios. Eighteen years later, the project finally came to fruition with Darabont now a lauded director of several Stephen King film adaptations — notably *The Shawshank Redemption* and *The Green Mile* — Nicotero one of the industry's leading creature effects designers and Burrell a visual effects supervisor at CafeFX.

"It was ironic," reflected Nicotero. "After all the prestigious films Frank had done, and being such a fan of the genre, this was the first time he had an opportunity to design his own creatures. It was an intricate design procedure; and, as I had known him for so long, Frank allowed me to drive that process. We brought in some great artists — Aaron Sims, Andy Schoenberg, Bernie Wrightson, Michael Broom, Jordu Schell — and I had my own ideas. We decided the creatures were not monsters; they were animal species from a different dimension, and they all had specific forms and functions. When a tentacle-creature reached in and grabbed a character, it was an exploratory act, which was a much more interesting concept than a mindless monster out to eat human beings."

The scope of the creature designs and decisions regarding divisions between the physical and digital effects were laid out in an early meeting at CafeFX. "Frank had been excited about the effects we created for *Pan's Labyrinth*," commented Everett Burrell. "He was fascinated by the way we had set up a production pipeline for creature effects on a relatively small budget. He wanted complete control; and, in order to do that, he'd worked out a deal with Dimension Films for a much lower cost



than he had originally conceived.” Darabont’s plan — eight weeks of preproduction followed by a frenetic six-week shoot — included filming in Shreveport, Louisiana, where production designer Gregory Melton found locations and erected a set representing the Bridgton Food House, and shooting with a Fox Network television film crew. “Frank had directed a couple of episodes of *The Shield*. He really liked how fast the crew moved, and that set up his thought process for using frenzied camera work on *The Mist*. It was a different style of filmmaking for him.”

The documentary style dictated a nimble approach for integrating visual effects. “We built a digital supermarket based on blueprints of the sets,” explained Burrell. “I took photos of the creature maquettes at KNB, we built digital proxy creatures and animated them with proxy mist. We then went to a company called Crack Creative, in Hollywood, where they had a previz camera system that enabled us to do handheld camera work in a virtual world.” Joshua Kolden, president of Crack Creative, implemented technology that allowed camera operators to perform real-time camera moves around predetermined clips of 3D animation. “It was based off sound, using sensors on the ceiling. We had a little handheld viewfinder, which allowed us to change lenses and move through the set, and we got through 30 to 50 setups a day. The previz was just a guide because it was all about the frenzied coincidences that happen on set. As Frank described it, this was like jazz, whereas his earlier films have been more like classical music.”

Darabont initially planned to open the movie with a prologue revealing origins of the mist, elaborating on King’s novella, describing an accident at ‘The Arrowhead Project.’ “The idea was the military had opened a portal to another world,” said Burrell. “They had a bathysphere about to enter, lightning zapped the generators and the mist broke out. They started building the set at an abandoned National Guard armory. Physical effects was planning a system of air cannons to shoot mist and glass out when it exploded. As we got closer to shooting, we ran out of time and money, so the scene was cut.”

The mist is, instead, first seen after a violent storm as it descends on the lakeside home of David Drayton (Thomas Jane). CafeFX depicted the oncoming storm with a digital matte painting seen through a window in the Drayton home, and digitally enhanced exterior devastation as family members venture out to see the mist rolling toward them over the mountains. “Frank wanted the mist effects to look alien,” stated Burrell, “but not scary enough to frighten characters away on first sight. He wanted to base the effects in reality. He didn’t mind using CG elements, but he didn’t want to see CG by itself, and he didn’t want to use chemical cloud tank elements. It had to look like an odd natural phenomenon.”

CafeFX CG supervisor Akira Orikasa led research and development to generate digital mist elements using Cebas Computer ThinkingParticles and Ideate FumeFX. Artists applied wind forces to shape simulations around 3D objects in Autodesk 3ds Max, and then allowed the simulations to unfurl. CafeFX also shot high definition digital footage of dry ice elements against black, pouring vapor over forms representing geometry in the production plates. Compositors then blended practical and digital elements, layering shots with 3D geometry to create effects of the mist colliding with and occluding objects.

For scenes inside the Food House, the production created in-camera mist effects using large quantities of glycol mist that physical effects supervisor Darrell Pritchett’s team pumped into the

tented supermarket set. “We had a couple of greenscreen window shots to help us get the mist up to the market,” said Burrell, “but once the mist touched the store front, it was all practical. It made sense from a budget point of view — otherwise we would have had a thousand greenscreen shots looking out the window. Outside the big interior was an exterior set with forced perspective lamp poles extending a good ten car-lengths into the mist so we could shoot angles out the front window.”

The creatures first attack a young bag boy, Norm (Chris Owen), dragging him through a partially rolled-up loading bay door in the back of the store. Darrell Pritchett’s team generated a wall of mist visible beneath the roll-up door by pumping mist into a tented area beyond the door. KNB provided a variety of tentacle puppets for the scene, which Greg Nicotero directed as second-unit inserts. “Bernie Wrightson, Aaron Sims and I designed the tentacles,” Nicotero recalled. “We did a little bouillabaisse of our ideas, including design aspects of giant squids. I remembered the giant squid in *20,000 Leagues Under the Sea* — its hooked beak was hidden in its flesh and it would come out and snap. We emulated that with little hooks, like sea anemone mouths, that pushed in and out as the tentacle opened up and grabbed its victim.” KNB designer Jeremy Aiello sculpted open and furled versions of the tentacle, and mechanical designers Jeff Edwards and David Wogh engineered insert sections representing portions of the creature’s 14-foot-long limbs. “We used multiple four-way cable sections so tentacles could move up and down and curl back on themselves. We attached those to a doorway dolly, which we could roll forward to make tentacles reach in underneath the door.”

CafeFX then enhanced practical tentacles digitally. “The intent was always to have the tentacles half CG and half practical,” said Burrell, “but when we got on set, Frank wanted them to move really fast and have an organic earthworm-like undulation that the puppets couldn’t do. KNB did a great job on the tentacles artistically, and they were very useful for the actors on set, but we replaced most of them digitally.”

To assist the integration of animated tentacles, CafeFX matchmove lead Kevin Hoppe placed LED and fluorescent tape tracking markers on set, then photo-modeled plates. Compositors used grid warping to deform tentacle contact points, combined with sometimes shocking physical effects. “For Norm’s death,” explained Nicotero, “we filled a bunch of blood balloons, covered them with latex ‘nurnies’ and silicone strips and attached them to the actor. One of our puppeteers — Shannon Shea — wore a green arm glove with tacks on the fingers. On ‘action’ he would reach in, grab the balloon and tear the flesh away. Everett then added the tentacle over the top of the green arm, with all our



Visual effects supervisor Everett Burrell manipulates a creature puppet for director Frank Darabont’s adaptation of Stephen King’s novella, *The Mist*. Darabont, a long-time genre fan, invited a close collaboration with Burrell and their mutual friend, creature effects supervisor Greg Nicotero, who oversaw design and creation of practical creatures and makeup effects at KNB EFX. Special effects supervisor Darrell Pritchett supplied mechanical effects and physical mist effects on soundstage sets in Shreveport, Louisiana. Burrell then enhanced practical effects with digital creatures and environment effects at CafeFX.

interactive blood hitting the actors' faces and spraying into the air. When I showed the first test to Frank, he said, "Tom Savini would be proud!"

Smaller, bug-like creatures next appear on the storefront windows, attracted by flashlights brandished by characters within. KNB designed bugs inspired by electron microscopy images of insects and nature reference of crabs. KNB artists Gino Gognale and Jeremy Aiello sculpted varieties of 18-inch bugs with armadillo backs, scorpion stingers and crablike mandibles, then manufactured multiples with vacuform wings and sucker feet for adhering to windows. Jeffrey Edwards' team mechanized closeup versions with articulation in the head, eyes, mandibles and mouth. KNB also constructed reloadable hollow latex bugs stuffed with silicone, latex, tissue paper and UltraSlime to splatter underfoot. CafeFX replicated bugs digitally and interspersed them among the practical puppets. "We built little sucker pads that could animate with blend shapes that flattened out against the glass," said Burrell. "We then added texture maps so that every time a bug moved its feet it left little oily footprints."

Bugs served as prey for larger, winged creatures in the next wave of attack. Andy Schoenberg, Bernie Wrightson and Michael Broom developed winged creature configurations that strove to avoid obvious prehistoric and dragon-like designs. "We started talking about the X-Wing fighter from *Star Wars*," recalled Nicotero, "and all of a sudden we thought, 'Wouldn't it be interesting to give the bird two symmetrical pairs of wings, one on the top and one beneath that, forming an 'X'? The top wings were used for lift, the lower wings were for steering; and when it landed, the back wings folded back like a bird, while the front wings moved like a bat." KNB designer Andy Schoenberg sculpted the bird creature maquette and, with Aki Horohito and Steve Koch, devised a full-size puppet with a wingspan of eight feet, articulated via a boom at the creature's back. "We locked down the feet; and the boom arm moved the creature up and down, or side to side. The neck was on a four-way cable, so that could move side to side and up and down. The jaw was a three-part mandible, radio-controlled. It had circular eyeballs on slight stalks, and we took a cue from nature to make it blink like a bird. We rigged a radio-control mechanism that pulled the eyes back through a silicone section in the head, and the weight of the silicone closed the lids around the eye."

KNB rod-puppeteered wing action and employed a hand-puppet attack head for insert shots. CafeFX then generated a digital bird creature that animation supervisor James Straus and his team used for more mobile and airborne shots. "The birds ate the bugs," said Burrell. "It became such a frenzy that the birds smashed into the glass and eventually broke a hole in the front window where the bugs and birds got in." CafeFX used luminance keys and difference mattes to place digital creatures behind physical breaking-glass effects, and hand-tracked 3D flashlight beams to illuminate the chaos.

Drayton sets fire to a marauding bird, which then continues to fly around the store. To create firelight effects, Darrell Pritchett's team rigged a boom arm that lowered a burning pyrotechnic element through set. "We shot with real fire wherever possible," stated Burrell. "That gave us interactive light around the store and reflected in the windows. We then animated our bird to match what the rig was doing on set." To shoot scenes of Drayton felling the burning bird and beating it to death, Pritchett's team rigged a small pyrotechnic cage on a pneumatic boom and dragged it through the scene. "Tom Jane hit that thing with a baseball bat all the way down the aisle, and every time he hit, we got all the residual sparks to bounce off this little football shape

made of chicken wire.” Compositors added the digital bird with CG flames generated in ThinkingParticles and FumeFX to fill in the gaps. As a final coup de grace, KNB ignited a silicone and polyfoam charred version of the bird for Thomas Jane to pummel.

Survivors next encounter giant mutant spiders during an expedition to a pharmacy adjoining the market. Jordu Schell sculpted a spider maquette that represented King’s description from the novella; but, in the translation to screenplay, Darabont incorporated a new design quirk. “Frank wanted the spiders to have an almost-human grinning face,” said Nicotero. “We didn’t want it to be literally a guy’s head stuck on a spider’s body, like The Zanti Misfits, so Mike Broom and I came up with a design that looked like a grinning death’s head when the spider closed its mandibles over its mouth.” KNB shop supervisor Mike McCarty and designers Jake McKinnon and Rob Derry contributed to the building of a three-foot spider puppet that incorporated eight legs and a spray of porcupine-like quills. Jeff Edwards engineered mandible and eye motion.



Large, winged creatures infiltrate the Bridgton Food House in rural Maine, terrifying shoppers trapped by the mist. CafeFX generated bird creatures for ambulatory and airborne scenes, based on photographic studies of KNB puppets and maquettes. KNB expanded on descriptions in Stephen King’s book and incorporated nature reference to create a surreal ecosystem from another dimension. The bird-creature design included a four-way wing configuration – suggested by a Star Wars X-Wing – and a bifurcating lower jaw.



For closeups of the bird creature attacking shoppers, KNB created full-scale puppets, including an animatronic version with an eight-foot wingspan. Artist Shannon Shea attends to the paint scheme.

CafeFX generated all mobile spider creatures digitally, and created digital effects for acidic spider webs that shoot from the spiders' abdomens to slice through flesh like scalding wire. "James Straus' animation team built a very clever keyframe Maya web rig," related Burrell. "It fired a long thin strand with 'bones' that could contract and move down a spline. We set up point A and point B where we wanted web to go, then slid the web along and broke up the pattern to gave it some noise." Spider webs slice into their targets, emitting acrid smoke, generated in 5D Smoke for Eyeon Fusion, which compositors blended with practical smoke and blood effects.

Early in the sequence, survivors encounter the barely-living remains of a military policeman and husks of other victims bound into webs festooning the pharmacy. KNB created a prosthetic makeup for the scene. "We gave the performer a chest prosthetic with gelatin blisters and bladders underneath," said Nicotero. "As he started struggling, we inflated the bladders to make it look like there was something moving under his skin. CafeFX augmented that with CG blisters popping and little baby spiders crawling out across his face."

The MP then falls to the ground and explodes, emitting thousands of baby spiders. "I shot the actor falling into a mat," said Nicotero. "We kept the camera locked off, took the mat away and replaced the actor with a silicone likeness puppet built by Jake McKinnon and Mike McCarty. It was rigged to drop the same way every time. When it landed, pistons broke the back open like a watermelon, with silicone strands and blood attached to the insides. Everett took a composite of the puppet's back and comped that to the actor, so it all appeared to happen in one shot. CafeFX then added thousands of CG spiders."

Spider attacks continue as survivors make a bid for freedom, running out into the mist, heading for Drayton's truck. Moments before making his escape, store manager Ollie (Toby Jones) falls victim to a crustacean giant that looms out of the mist, the one creature designed by CafeFX, rather than KNB. "Our resident concept artist, Lei Jin, worked up the design," noted Burrell. "It was a low, scuttling thing, with big lobster arms." Darabont filmed the scene by whip-panning up from Toby Jones, then tilting back down to the gory aftermath. "We see Ollie pulled up into the mist, kicking in silhouette. A big maw opens, chomps down and then pulls away and leaves just legs dangling. It's all CG, even the blood landing on the car. Frank didn't have time to splatter the car with blood and wipe it off for re-takes; so our lead animator, Greg Jonkajtys, painted texture maps, animated blood and tracked it in."

Characters drive away from the supermarket, then pause on a desolate mist-shrouded highway as an almighty behemoth strides by, stepping over the car. Nicotero and Burrell prevailed on Darabont



Frank Darabont lines up a shot using a full-scale KNB maquette of a giant arachnid, one of a colony of mist creatures that characters encounter in a pharmacy adjoining the Food House and in a parking lot. KNB created a three-foot mechanical spider articulated with mandible and eye motion. CafeFX created all of the mobile and scuttling spiders digitally.

to include the scene in the screenplay, reinstating it from the King novella. “It was not in the script,” stated Burrell. “Frank didn’t feel that it was dramatically important; but Greg and I both felt it was a moment that every Stephen King fan was living for.” After giving the idea some thought, Darabont asked CafeFX to storyboard the scene. “We showed our storyboard to Frank — but he still wasn’t into it. It wasn’t until we started temping it out that he became excited. He showed the scene to Stephen King, and Stephen loved it. It’s only two shots, but they are standout shots.”

The enormous creature, over 300 feet tall, was based on a Bernie Wrightson rendering, inspired by H.P. Lovecraft. “I had an illustration in an old Lovecraft book that looked like elephant legs topped by a mass of writhing tentacles,” recalled Nicotero. “I talked about it with Bernie; and he did some sketches of this huge creature with a ring of tentacles around its head, a weird mouth and long, overlapping teeth. It had cockroach legs along its abdomen and six giant alien legs under that.” Jeremy Aiello sculpted the behemoth as a maquette, then as a six-foot-tall puppet intended for articulation as a marionette. “Frank wanted to do it old-school. He wanted a miniature car with a puppet creature that could just walk over top of it, which we’d shoot by pulling back from the miniature as it walked past, and maybe angles looking up.”

When the miniature approach proved inflexible, CafeFX scanned the KNB maquette and built the creature and its environment digitally. “The Land Cruiser and the road were CG,” noted Burrell. “The creature lumbers across, taking out a few telephone poles and interacting with the ground. It was so huge it had its own ecosystem. We animated parasites crawling on it and bird creatures flying around like seagulls on a dead whale. In the second shot, it moves off through the trees and we see a glimpse of its face and tentacles on top of its head. It’s very Lovecraftian. The scary part is what you can’t see.”

The film concludes with a dramatic twist that took characters beyond King’s novella — but elaborations on plot and creature designs received the author’s seal of approval. “Stephen King had 150-percent confidence in his director,” asserted Nicotero. “He told Frank, ‘If that is the movie you want to make, I’m with you.’ It was intense. It was bleak. But this was the story the director wanted to tell. It was my job and Everett’s to pull off the creatures. We worked so well together because of our friendship and mutual knowledge of creature effects and visual effects, and we are both tremendously proud of the results.”



Several survivors escape the market in a sport utility vehicle and come to a halt on a desolate mist-shrouded highway, dwarfed by a 300-foot-tall behemoth that steps over their car. Nicotero and Burrell lobbied the director to incorporate the scene from King’s novella into the screenplay, and developed a creature design that featured traits inspired by classic H.P. Lovecraft tales. When Darabont assented, KNB produced a maquette and six-foot-tall puppet that was to be articulated through marionette techniques. CafeFX ultimately scanned the maquette and built the creature, SUV and environment digitally.

Overview

Tom Schelesny on *Enchanted*

Article by Estelle Shay

When it comes to animated features, nothing can surpass the timeless appeal of such cinematic treasures as *Snow White and the Seven Dwarfs*, *Cinderella* and *Sleeping Beauty* — beloved ‘happily-ever-after’ tales whose saccharine-sweet charms, plucky heroines and catchy tunes have earned them a special spot in the pantheon of children’s classics. But put the distilled-down essence of those films on a collision course with real-world aesthetics, and the result is a recipe for comic disaster. Such is the premise of Walt Disney Pictures’ current release, *Enchanted*, in which a young princess, banished from her perfectly ordered and animated cartoon world, is thrust into the chaotic midst of modern-day Manhattan.

Though it was a premise that invited some fun at the expense of the Disney classics, director Kevin Lima — a former Disney animator who later segued into directing — envisioned an approach to the material that was more of an homage to Disney than an irreverent send-up. “When I first met Kevin,” recalled Tippet Studio’s Thomas Schelesny, who was brought onboard to supervise visual effects for the production, “he started by saying that this film was going to be done in honor of the Disney work, not in fun of it. That’s tough, because you want to poke a little fun, but you can only make so much fun of something before it comes off as mean humor. So we needed to find a good balance that would allow us to stay true to the genre and really honor the tradition behind the work.”

Enchanted opens with a 14-minute-long traditionally animated prologue, created by master animator James Baxter, who honed his craft during two decades with Walt Disney Animation Studios and DreamWorks Animation prior to launching his own company, James Baxter Animation, in Pasadena. The prologue introduces viewers to the idyllic cartoon land of Andalasia and the treehouse home of a young princess, Giselle. Befriended by a chatty chipmunk named Pip, and surrounded by a bevy of adoring woodland creatures, Giselle dreams of, then meets her true love in the form of the handsome, if somewhat dimwitted, Prince Edward. Events take a nasty turn, however, when the prince’s scheming stepmother, Queen Narissa, shoves the unsuspecting princess down a magic



well, seemingly to her doom. Instead — as 2D abruptly gives way to live-action — Giselle is ejected out of her cartoon fairytale and into the jarring reality of a jaded real-life metropolis.

Tippett Studio was assigned the bulk of the visual effects for *Enchanted* — some 320 shots featuring mostly character animation. Other contributors included CIS Hollywood, responsible for 36 composite shots and wire removals; Reel FX, which contributed four shots in the film's epilogue featuring some tricky transitions from a pop-up storybook to live-action; and Weta Digital, which handled two similar transitions in the prologue. Makeup effects were provided by Rick Baker's Cinovation Studio, and special effects were supervised by Mark Bero.

For Tippett Studio — renowned for its character animation — *Enchanted* offered a unique opportunity to delve into the Disney mystique. “Since Kevin Lima was very focused on this being a true homage to Disney, we knew we had to completely immerse ourselves in the genre. We were lucky in that Kevin's background is Disney 2D; he comes from that world. So we put together a series of reference videos and animation notes to try to design, internally, an approach to the work. From that, we developed an animation training program at Tippett to instill the Disney aesthetic into our animators, and then we spent our preproduction period teaching them to be a different kind of artist.”

At the heart of the assignment was the design and creation of a computer generated Pip for shots featuring the chipmunk in the real world, where he ventures with Edward to rescue Giselle. As a comic foil with a pivotal role in the narrative, the character demanded a photoreal, nuanced performance that also took into account the 2D version of Pip introduced in the prologue. “We were keenly aware of the fact that James Baxter — who is one of the top living animators in the world today — was doing the animation for the opening; and we knew that the 2D version of Pip would basically set the mark for what the character was going to be like. But our Pip lived in the real world, and had to be believable. He not only had to look like a real chipmunk, but we wanted to prove that he could move like a real chipmunk, too. Otherwise, we would be breaking the reality of the live-action setting.”

Schelesny and Tippett crew members traveled to Los Angeles to meet with animal trainers who had been working with a real chipmunk for use on set — an idea that was later scrapped. “Chipmunks are not easy to train. They'd been working with this animal for about six months, and it was reliably able to do very little. It could run from one box to another — and half the time it would just run away. But we did get a lot of excellent reference on how chipmunks really move, and what they look like up close; and we used that as our basis to design the character initially.”



For the Walt Disney fantasy *Enchanted*, director Kevin Lima serves up an homage to the studio's animated classics in the form of a tale depicting the comic clash of cultures that arises when a stereotypical fairytale princess and her storybook friends are magically transported to modern-day New York. Visual effects supervisor Thomas Schelesny led a Tippett Studio team in crafting visual effects for the film, much of it invested in character animation entailing the photoreal depiction of an all-CG

chipmunk named Pip, who features prominently in the narrative.

Under lead modeler John Koester and lead painter Tim Odell, a photoreal CG Pip was created, with fur stylings for both dry and wet looks, painted in color patterns that matched Baxter's 2D version. Odell later added additional detailing for closeup views of the character. "We had a good idea what Pip physically needed to do in order to get the storyline across; but as sequences were being cut together, we saw the rapport that Pip could build with the audience, and realized we needed more closeups. So Tim went back and added additional detail to the reflections in the eyes, and the wet meniscus of water where the eyelid meets the eyeball. That was critical with big dark eyes like Pip's, because the first thing you want to do is look deeply into them. Overall, the paint job for the character really stood out, which was a credit to the fur styling, the actual design of the fur itself, and how it was laid out — all of which was done by John Koester."



Stripped of his powers of speech in the real world, where he has gone in search of Giselle, Pip communicates via pantomime in a desperate attempt to foil a plot — hatched by the evil Queen Narissa — to harm the unsuspecting princess. Tippett modelers gave the chipmunk a detailed, photoreal look capable of withstanding closeup scrutiny, while animators downplayed the cartoon aspects of the character in favor of a more subtle, artful performance that played up the pathos of Pip's predicament, and encouraged audience empathy.

A bigger challenge was finding ways to create an anthropomorphized performance for the high-energy character that would still sell in the real world. "In the 2D world, Pip is up on his hind legs and talking with a Brooklyn accent. But when he gets to New York, he loses his ability to speak, and is reduced to uttering chipmunk sounds — mostly gibberish — and relying on pantomime to get his point across. So one of the first decisions we made was that when Pip was running from place to place he would run as a real chipmunk on all fours, but when he stopped — if the performance justified it — he could hop up onto his hind legs and stand and gesture almost like a person."

Schelesny soon discovered that the Disney animation aesthetic he and his team were striving to emulate was something of a moving target, and difficult to pinpoint. "It was a matter of 'when it feels right, then it is right,' but you can't teach that to somebody. It's not specifically how the computer model is built or how the animator poses the character, or the facial expressions he strikes. With Pip, we were more concerned with how he would be perceived — not how does he move or does his pose look strong, but what is the goal of the shot and how will the audience relate to him. We weren't just looking for a bunch of gags to carry the humor. We actually wanted the audience to like Pip, to be going along for the ride with him. He is the only character in the movie who knows what's going on, even if he can't tell anyone about it. He knows, and the audience knows — which makes him the perfect catalyst to bring the audience through this film. So even though he is a fast-talking, sly character, we really wanted to build a sense of empathy for Pip. If he were smarter than everybody, thinking faster than everybody, a step ahead all the time, there would

never be a challenge for him. But Pip is always just a step behind. So we were very specific in trying to draw on that pathos. It was building that vulnerability into Pip that makes you root for him.”

Since Pip could not express himself through speech, animators had to rely primarily on body language and facial expression to define the character — not an easy task given Pip’s large black eyes, which made it difficult to communicate emotion, or even tell where he was looking much of the time. Schelesny and his crew did extensive R&D on facial expression development, pulling together volumes of material from Disney archival reference, and exploring such questions as how far to push the face rig, designed by puppet supervisor David Nelson. “There’s a fine line between being expressive and being unsuitably exaggerated, which would have made Pip seem more like a cartoon character than a real chipmunk.” To avoid such pitfalls, animation supervisor Tom Gibbons and character animation lead James Brown developed a package of 2D illustrations delineating specific expressions. “James took the base Pip CG head and began manipulating it to a series of about 20 facial expressions that we thought were relevant to the script, and that could be used perhaps more than once. These facial expressions weren’t baked into the model, but instead were posed using manipulators. They were a jumping-off point. Using the animation controls, the animator could call up a particular expression and then modify it to work appropriately in each shot.”

In addition to Pip, Tippett Studio provided photoreal CG creatures for one of *Enchanted*'s most comical and effects-intensive sequences — a musical number reminiscent of the “Whistle While You Work” scene in *Snow White*, but with a bizarre twist. Taken in by a friendly and compassionate New York divorce lawyer, Robert McKenzie (Patrick Dempsey), Giselle (Amy Adams) decides to clean his messy apartment while he sleeps. When she attempts to summon her woodland friends to lend a helping hand, however, Giselle is greeted instead by the city's version of wildlife in the form of roaches, rats, flies and pigeons, who emerge from every crevice, drain and sewer within calling distance of the apartment. The vermin — in comic contrast to their furry 2D counterparts — perform such disgusting acts as licking clean the dirty dinner plates and putting them back in the cupboard, scrubbing toilets with Robert's toothbrush, and nibbling on bathtub grime — all done to the accompaniment of a cheery tune sung by Giselle.

The sequence featured a seamless blend of live-action and computer animation, with real animals used to fill out the scene or perform simple maneuvers and CG critters inserted whenever the action called for more complicated behaviors. Swarms of roaches and clouds of flies were accomplished with a particle system created by lead effects animator Clear Menser. The musical demands of the sequence added a further level of complexity. “I'd never worked on a musical number before, and that was an entirely different set of challenges. We weren't looking for over-the-top cartoon animation — we played it straight. It had to look like real animals helping Giselle clean the house, as that would serve to underscore the absurdity of the situation. But we also had to hit very specific beats, which was not only difficult to animate, but incredibly difficult to shoot in terms of the backgrounds.”

Plate photography for the sequence was captured on a stage at Steiner Studios in Brooklyn. “We were working to pre-recorded music, with performance notes that had to happen in each shot at a certain time and on a certain beat, but there were also complicated camera whip pans, with floor effects occurring simultaneously. In some cases, I chose to shoot at 12 frames per second so that everyone was moving at half speed. That allowed us to slow things down a bit and hit our marks accurately.”



Taking up temporary lodging in the apartment of New York bachelor Robert McKenzie, Giselle (Amy Adams) leads a chorus of rats and pigeons in song as hoards of vermin emerge from drains and sewers to cheerfully tidy up the messy abode. The ‘Happy Working Song’ – an homage to the ‘Whistle While You Work’ number in Snow White and the Seven Dwarfs – featured a seamless blend of real rats and pigeons, captured on set or against greenscreen performing simple maneuvers, and computer generated creatures, composited into the mix whenever the action demanded more complex behaviors.

Schelesny captured greenscreen elements of the real animals to supplement the live-action. For a shot of rats pouring out of a street sewer and skittering toward the apartment, a real sewer grate was filmed on the streets of Manhattan, and then re-created as a green set piece on the stage, where hundreds of real rats were released. “Nothing beats the real thing; and it was pointless to have all these trained rats and pigeons running around on set, and not try to get as many practical shots as we could. So I put together a list of elements I wanted to shoot, and carefully choreographed how I wanted to shoot them. In one day we completed 68 greenscreen setups for the pigeons alone, and some very specific things — like the sewer grate shot — for the rats. It was very intense, but we got everything we needed.”

In another segment, Tippett artists worked in collaboration with James Baxter Animation to create a series of shots depicting the 2D Queen Narissa communicating with her squire, Nathaniel (Timothy Spall), whom she has sent into the real world to track down the princess and kill her with a poison apple. As Nathaniel navigates the streets of New York, the haughty cartoon visage of the queen — transmitted magically via liquid mediums — periodically grills him on his progress, popping up in such unlikely places as a vat of soup, an aquarium, a water bottle and a martini glass.

Animators received 2D elements of Narissa from the Baxter team, then integrated them into their 3D environments, sweetening the gag with the clever use of water effects, bubble effects and additional distortion. “One neat trick that our lead compositor Chris Morley came up with was an ink effect to imply that not only was Narissa 2D animation, she was 2D animation painted on a cel that would slowly bleed colored ink into the water. Baxter provided us with animation elements broken into layers of line art and color. Then we made the purples bleed a smoky bluish-purple cloud into the water that reacted to Narissa’s movements. It was a funny little idea, but it really helped lock her in the environment and add some real-world physics to the scene.”



A pair of CG pigeons and a flying formation of CG cockroaches groove to the music during the ‘Happy Working Song.’ Given the musical demands of the sequence, Tippett animators had to hit specific musical and performance beats in crafting their CG character performances, while Schelesny faced similar challenges in capturing the live-action backgrounds with Adams and a slew of real animals on the set.



In a climactic end sequence, a soggy Pip performs a daring rescue atop New York’s historic Chrysler Building during a raging rainstorm. Tippett modelers experimented with different fur stylings and paint detailing for the chipmunk in order to create a convincing look for Pip’s rain-soaked fur.

Animators further upped the ante by introducing such 3D elements as fish swimming in the aquarium and olives floating in the martini glass. “There was one shot where Narissa appears in a pot of soup, and there are apples bobbing on the surface. While making a point, the 2D Narissa reaches up to the surface of the liquid, grabs one of the apples and brings it under the water. Kevin thought it would be interesting if the apple turned into a 2D element once she has her hands on it, then back into a real apple after she lets it go and it bobs to the surface. That required quite a bit of back and forth with James Baxter Animation — a lot of planning on both our parts, and a lot of neat little sleight-of-hand that involved crossovers from 2D to 3D.”

Infuriated by Nathaniel’s failure to carry out her nefarious plans, Queen Narissa (Susan Sarandon) takes the real world by storm, entering through the magic portal, green lightning flashing from her fingertips. Disguised as an old hag — a makeup provided by Cinovation Studio — she follows Giselle to a grand costume ball at the city’s historic Woolworth Building, and foists the poison apple upon her. For a quick shot of Narissa transforming back into the regal queen, Tippett animators introduced a CG fire effect designed to set the stage for a more frightening transition to come. “Kevin wanted that first transition to be very quick, not a giant morph effect. It was a fast-paced scene, and he didn’t want to stop the action to watch a gratuitous visual effect.”

Effects animator Konstantin Promokhov spent months pinning down an approach to the digital fire, after initial iterations were deemed too realistic for the look of the film. “We went back to *Sleeping Beauty* and other Disney films, studying their effects animation — how they handled fire and smoke, which had a specific, dramatized look to it. Then Konstantin redesigned his fire to respect the physics of real fire, but have the look of a Disney animated flame.”

Having failed once again to dispatch the princess, Narissa utters an incantation and transforms into a 40-foot-tall reptilian dragon beast, visible in silhouette inside a swirling tornado of flames that reaches to the rafters of the grand ballroom. For the transformation shot, Tippett artists created a digital double of Sarandon from a Realscan 3D model of the actress, painted and animated to blend with the CG beast. The final composite shot, blending CG and live-action, was one of the film’s most complex and render-intensive. “Not only did we have the dragon, but there was an enormous amount of CG fire and smoke, maybe a hundred extras all reacting to the beast, stuntmen doubling as principal characters who had to be yanked out of frame, interactive lighting effects, and a huge series of interactive floor effects that all had to go off at the same time.”



*For a shot of Queen Narissa morphing into a 40-foot-tall reptilian beast designed to echo *Sleeping Beauty*’s haughty villain, Maleficent, Tippett artists began with a digital double of actress Susan Sarandon, animating it to blend with the emerging creature, seen in silhouette within a swirling tornado of digital smoke and flame. Compositors inserted the beast into background plate photography that included a complex array of interactive lighting and floor effects.*

The Narissa-beast’s physical appearance proved tricky to pin down, as Lima sought a look for the creature beyond that of a typical dragon — incorporating some of the physical attributes of Sarandon. Artwork by noted illustrator Mark ‘Crash’ McCreery provided the impetus for a creature maquette sculpted by Peter König that captured the actress’ striking eyes and iridescent costume.

Working with the maquette and Sarandon's costume as reference, Tippett artists incorporated the red and blue pearlescent look into the dragon's scales, with the final effect achieved via a shader developed by CG supervisor Davy Wentworth and an intricate paint job by artist Negin Bairami.

Channeling Maleficent in *Sleeping Beauty*, animators imbued the beast with a regal and arrogant demeanor, moving her in a slow, serpentine manner as she snatches up Robert, smashes out a wall of the building and climbs onto a balcony high above the city, in the midst of a raging storm. "Tom Gibbons designed a slow, controlled look to the beast's movements that would suggest a sense of power. We really wanted to hold her back and imply her strength by her not needing to demonstrate it." CG artists substituted one entire wall of the ballroom set piece, where the live-action was shot, with a digital replacement, adding giant panes of glass shattering as the beast smashes through.



Fully transformed, the Narissa-beast snatches Robert— a digital double created by Tippett — from a crowd of stunned onlookers attending a costume ball. Artwork by 'Crash' McCreery and a creature maquette by Peter König provided the impetus for designs of the Narissa-beast. To further sell the effect, Tippett artists incorporated aspects of Sarandon's facial features and iridescent costume into the look of the creature, rendered via custom shaders and an intricate paint job and composited into the shots.

In a final showdown, the beast climbs up the outside of the skyscraper, with Robert in her grasp and Giselle in hot pursuit. Schelesny prevized every setup for the sequence, working with storyboard supervisor Troy Quane to map out camera angles on a rough videomatic, shot with a lipstick camera, foamcore mockup and doll figures. The approved videomatic was then delivered to Tippett for reference in creating a more detailed and accurately scaled previz that was digitized for playback on a bluescreen stage, where Amy Adams was filmed.

With the exception of the bluescreen elements, and additional greenscreen inserts of Patrick Dempsey captured on an armatured rig for closeup views of Robert in the dragon's grasp, everything else in the sequence was computer generated — including New York City backgrounds, supervised by Matt Jacobs. The skyscraper — a near-precise CG replica of the real Woolworth Building — was modeled by John Daniels and painted by Ben VonZastrow. VonZastrow also devised a rain shader to simulate water sheeting down the exterior of the edifice. Additional weather effects by Clear Menser took some liberties with realism, using rain, wind and lightning as a subtle dramatic device to help drive the story. "We wanted the rain to have some of the characteristics that we saw in *Snow White and the Seven Dwarfs*. So we put together a simulator that allowed us to control exactly when the rain would swirl, what direction it would swirl in and how fast it would swirl. In fact, if you watch the sequence with that in mind, you can see that the lightning starts very far away from the building, and slowly — as the sequence plays out — grows closer and closer until we get to the shot where the beast has Robert in her hand and is about to throw him to his death, and the lightning and rain are all around her."

Not surprisingly, *Enchanted* ends in the way that all Disney animated classics end — happily ever after. For Schelesny and the Tippett team, the project had its own happy conclusion, with test

audiences responding warmly to the film. “If there’s something classic Disney animation understood, it was how to appeal directly to an audience. This basic form of communication transcends language itself, and goes to the core of how we feel, experience and react to our world. Disney broke that down and identified, in a very pure sense, how to get inside our heads and how to strike a real chord with viewers. On so many levels, I think *Enchanted* is one of those few projects that absolutely captured that.”

Enchanted photographs copyright © 2007 by Disney Enterprises.

All the Way

image

ARTICLE BY JODY DUNCAN

A question often raised when the uninitiated first view a scene from *Beowulf* — the latest performance captured computer animated film from director Robert Zemeckis — is, why. Though the movie features two types of supernatural creatures that are commonly the work of computer animation, its many human characters are so stunningly lifelike, one wonders why a filmmaker would choose to realize them via the laborious performance capture process: recording actors on a motion capture stage, cleaning up and editing the data, enhancing it with keyframe animation, lighting and rendering synthetic characters in excruciating detail — down to the peach fuzz on their faces — and then integrating them into similarly detailed environments. If the final CG performers are going to so closely replicate real actors in a real world, why not film real actors in a real world and get the peach fuzz for free?

That question has been fielded often by visual effects supervisor Jerome Chen, who acted as co-supervisor with Ken Ralston on *The Polar Express* — the groundbreaking 2004 film for which Zemeckis and Sony Pictures Imageworks employed advanced motion capture technology to drive the performances of CG characters. Chen's answer to the question of 'why' can be summed up in one word: control. "If a director has an exact vision of what he wants his film to look like, this technique is the only way to accomplish that," Chen offered. "Bob had an exact vision for movies he'd made before; but like every director, he'd had to compromise that vision because of the realities of filmmaking. There are physical realities, budget realities — all kinds of limitations. For example, you might get a perfect performance from an actor on the first take, but then discover that the camera wasn't quite right. You finally get the camera worked out on the sixth take; but by then, the actor has lost his energy, and his performance isn't as good. So you compromise and choose the best take, even though you didn't get exactly what you envisioned. Accepting that kind of compromise can be gut-wrenching for a director — especially one with a very clear vision."

In contrast, computer generated films that employ performance capture enable a filmmaker to isolate and record actor performance without the distractions and potential misfires of camera, lighting, sets and costumes. "By making a movie this way," said Chen, "Bob can shoot the performance first, without worrying about anything else. And then, once he has the performance captured, he can begin to create the film cinematically. With the performances all locked, he can determine the camera work and the look of the entire movie."

Beowulf screenwriters Neil Gaiman and Roger Avary liberally adapted the Medieval-era epic poem for modern audiences, but retained the essential characters, such as the titular Geat warrior (Ray Winstone) who comes to the aid of the Danish King Hrothgar (Anthony Hopkins) when his Heorot Hall and surrounding lands suffer nightly attacks by a hideously deformed, raging monster. The creature, Grendel (Crispin Glover), is the offspring of Hrothgar and a beautiful, seductive half-woman/half-serpent (Angelina Jolie) who rewarded Hrothgar with his kingdom in exchange for their ill-conceived son. When *Beowulf* kills Grendel, the demonic 'merewife' lures him to the watery depths of her cave pool to seduce him and conceive another son, again promising a long reign as

king. Lustful and ambitious, *Beowulf* accepts the pact, and rules for thirty years — until his grown spawn from the underworld, a man-turned-dragon, emerges from the depths to destroy the kingdom. The aged *Beowulf* bests the dragon in a fierce battle and dies, finally fulfilling his heroic promise.

Zemeckis and the Imageworks crew realized the narrative utilizing performance capture technology that far exceeded the nascent ‘Imagemotion’ system Imageworks had developed for *The Polar Express*. The original setup had been comprised of 72 motion capture cameras that recorded Tom Hanks’ performance by aiming infrared light at tracking markers affixed to his face and a tight spandex body suit. Imageworks refined the system for *Monster House* in 2006; but the technology really hit its stride with *Beowulf*. “On *The Polar Express*,” said Jerome Chen, “we had invented something new, and so we were mainly dealing with technical challenges. By the time we got to *Beowulf*, we’d worked out the technical problems, and so our challenges were all creative ones. The biggest problem in working on a new visual effects project is that you spend 75 percent of your time just figuring out how to do it — which means you only get to spend 25 percent of your time making it look great and doing the creative part. ”

Housed on stage on the Sony Culver City lot, the *Beowulf* performance capture system was a state-of-the-art configuration designed by mocap supervisor Demian Gordon, a veteran of earlier Zemeckis mocap projects. The setup featured 16 digital video cameras to capture valuable performance reference and 228 motion capture cameras — four times the number used on *The Polar Express*. The increased number and overall higher quality of the motion capture cameras resulted in much better performance capture data. “The cameras used this time were 4-megapixel cameras, as opposed to 1-megapixel cameras,” Chen stated, “so they saw more data. That made a huge difference in the quality of the motion capture.” The improved system also enabled the crew to capture a much larger volume. On *The Polar Express*, the motion capture setup had been capable of capturing only ten square feet of volume at a time, requiring Tom Hanks to perform traveling scenes in ten-foot ‘chunks’ — performing a ten-foot section, backing up and continuing the performance as he covered another ten feet, and so on — all of the chunks tediously stitched together by technical animators using motion editing tools. “On *Beowulf*,” noted Demian Gordon, “we upped the space to 25-by-25 feet of volume, which allowed us to capture a larger scope of action and cut down on the number of individual performance layers we had to stitch together.”

The larger volume also accommodated a greater number of performers. “This time,” observed digital effects supervisor Sean Phillips, “we were able to get 21 characters with 76 props acting together at the same time, whereas on *Polar Express* we were only able to get maybe five characters at a time. That was a huge advancement.”

Another significant refinement was the use of electrocularography — EOG — to capture even the tiniest movements of the actors’ eyes. On *The Polar Express*, detailed eye movement had been animated



For *Beowulf*, director Robert Zemeckis reunited with visual effects supervisor Jerome Chen and the team at Sony Pictures Imageworks to expand the artistic and technological boundaries they had set with *The Polar Express*, their debut performance capture feature. As they had for that movie, the filmmakers recorded actor performances on a motion capture stage, and then applied

by hand, a process so time-consuming and labor-intensive, eye animation had been limited almost entirely to the main characters. “We hoped no one would notice the lack of eye movement on the background children,” Chen recalled, “but they did.”

For *Beowulf*, the crew affixed electrodes to the actors’ faces to capture the small electrical discharges of the muscles around the eyes, and then converted the data into animation curves. The result: synthetic character eye movements — even the smallest saccadic movements as a character searched the face of another, for example — were driven by those of the original actor. “That was a big leap in technology that we used for the first time on this movie. Being able to capture that movement, instead of having to animate it by hand, meant that all of the characters, even those in the background, had realistic eye movement.”

As on *The Polar Express*, actors wore body-fitting spandex suits and dozens of tracking markers to facilitate the motion capture process, and performed on skeletal sets designed to avoid obstructions between them and the mocap cameras. Also on the mocap stage were a variety of rigs provided by special effects supervisor Michael Lantieri to simulate interaction between the characters and yet-to-be-realized CG creatures and environments. One rig allowed the crew to capture swimming action on stage; another created the illusion that Angelina Jolie was treading water as she rose from the depths of the cave pool. To simulate *Beowulf*’s dragging through the forest by the dragon, Lantieri harnessed Ray Winstone or his stunt double to a dragging rig. Likewise, Winstone rode a large motion platform for shots of *Beowulf* straddling Grendel during combat. A similar motion rig was employed to simulate *Beowulf*’s ride on top of the dragon during the climactic sequence. Closeups of characters astride horses were shot with the actors atop simple spring rigs, maneuvered from below by the special effects crew.

that data to synthetic characters that were rendered in excruciating detail. Early in the film, the warrior Beowulf (Ray Winstone) sails to the land of the Danes to battle a monster who has decimated the royal court in nightly attacks.



Improvements in the performance capture system in the three years since *Polar Express* resulted in computer

generated characters that were more photorealistic and lifelike. Whereas the original setup had been comprised of 72 motion capture cameras, the system employed for Beowulf boasted 228 cameras, which recorded more performance detail. The cameras were also of a higher quality, capturing four times the data of the earlier camera models. In addition, motion capture crew members employed electroocularography, which enabled them to capture even the minutest movements of the actor's eyes, and thus imbue them with the spark of life.

As the mocap shoot progressed, Imageworks and Zemeckis began creating director's layouts of scenes. Equivalent to live-action dailies, the layouts were generated within a game-technology pipeline, and were comprised of the motion capture data — collected and interpreted by a heavily modified version of Motionbuilder, which Imageworks had used for *The Polar Express* — applied to crude 3D characters, with camera moves and angles incorporated. "We used the real-time strengths of game technology to help Bob quickly visualize the composition of his shots once his performances were selected," stated Chen. Though the characters and sets were simplified, they were in color and adequately realized to enable Zemeckis to block out camera movement with director of photography Robert Presley.

Working from the director's layout of each scene, Imageworks began preparing to create final shots — building environments, modeling characters from scans of the actors, tweaking the performance capture with keyframe animation, adding final camera moves using its virtual camera system, Wheels, and doing final lighting and rendering. The earliest shots generated for *Beowulf* reflected the painterly, stylized concept art produced by production designer Doug Chiang and his design group; but Imageworks moved toward a more photoreal look as production continued. "When we started building the characters and looking at the motion on them," said Jerome Chen, "we realized that the performance wasn't reading very well in those stylized characters. So we started adding things to make the performances read better. We added wrinkles and folds in the skin. We added moisture to the eyes. We added all of this stuff to the characters, which made them look more realistic and less stylized. We didn't start off intending to make these characters look photoreal or hyper-real. We just took them in that direction because that's what created a compelling performance."

The exceptionally fine detailing resulted in synthetic human characters that hovered dangerously near the 'uncanny valley,' a term originated by Japanese roboticist Masahiro Mori in 1970, referring to the discomfort some people experience when they observe robots — or CG characters — that closely replicate human beings. "The theory is that the more something resembles a human, the more repulsed the reaction," Chen explained. "But I don't believe in the uncanny valley. The fact is, despite the negative reaction by the critics to *Polar Express*, the public embraced the film. Now, with *Beowulf*, we hope to cross over that 'valley' by creating characters that connect emotionally with the audiences. To do that, we have to go all the way."

Driven by actors' performances, the movements and behavior of the synthetic human characters 'went all the way,' and were grounded firmly in the real world; but those captured performances

required some keyframe animation to make them read fully on screen. “Optical motion capture still doesn’t give you the volume of the lips and the insides of the mouth,” observed Chen. “We just can’t put enough dots on the mouth area to get that. So we did animation work to make the lips and mouths read. Overall, though, we used much less keyframe animation with the mocap this time than we did on *Polar Express*, because the motion capture data and our facial animation rigs were so much better. Still, we spent a significant amount of energy and time fine-tuning the mouth and cheek movements to reflect what the actor did.”

Imageworks riggers, led by Rick Grandy, built a huge array of body and facial rigs for the synthetic performers, tying them to a toolset that allowed animators to move quickly and easily between the motion capture and keyframe animation. “Because we could switch back and forth between motion capture and keyframe animation,” said animation supervisor Kenn McDonald, “we could look for key frames of the performance and animate within those frames to maintain the performance that was originally there.”

This toolset, improved body and facial animation rigs, and the advanced performance capture system all led to remarkably detailed and specific animated performances, despite the nearly 100 different characters in the film. “Our senior software lead, Parag Halvadar, created a system that could automatically take a generic facial rig and deploy it across dozens of characters,” explained McDonald. “This generic facial rig was the basis for all of the human characters. But then, as we worked with the performance capture data and looked at the video of the performances, we started noticing very small movements that were specific to each actor. There would be a little fold at the mouth or a little overlap in the corner of the nose that would move in a specific way; and so we’d build a custom control for that feature on that character. The final result was that we built customized rigs for the main characters. Each rig was individualized to suit that actor and to get the exact performance the actor had given.”

In response to a criticism leveled at *The Polar Express* regarding the lifeless quality of its CG characters’ eyes, the Imageworks crew paid scrupulous attention to the eyes in *Beowulf*. “We really studied eyes this time,” said Sean Phillips, “and broke down what we could do that we hadn’t done last time to make the eyes come alive. We did a full data acquisition of the principal performers’ eyes, scanning them and doing a range of photography on them, including extreme closeups. Then our human look development team — led by Francis Lui, Dennis Bredow and Jeff Stern — went about re-creating them exactly. One of the things we knew, for example, is that the cornea of an eye is actually sunken; so we re-created that. The cornea is also always refracting through the lens of the eye. It’s very subtle, but if it’s not there, it doesn’t look right.”



In addition to synthetic actors, the film had fantastic creatures such as the deformed monster Grendel (Crispin Glover). Production designer Doug Chiang created artwork to develop the look of the 12-foot-tall creature, including a maquette, which Imageworks scanned and modified in Maya. The creature’s texture paint scheme was inspired by photographs of autopsies and car accident victims, with a special RenderMan shader creating a shiny quality in Grendel’s open sores. Though early renderings incorporated some of Glover’s facial features, Grendel’s final look bore little resemblance to the actor.

Although tiny eye movements did not have to be hand-animated, thanks to the EOG data, eyes still required an animator's touch. "The EOG system was helpful," stated Kenn McDonald, "and we got a lot of useful motion and data out of it; but we found that we had to line it up and tweak it to really make it work in the shots. It would capture the actor's eye performance, but sometimes the character would appear to be looking off to the side, for example, and we'd have to realign that. Other times it would spike and do crazy things." Animators assembled a library of eye movements derived from the EOG, which could be easily applied to characters — not only hero characters, but background characters in crowd scenes, as well.

Hair and cloth, a dedicated department at Imageworks overseen by Sho Igarashi, completed the synthetic performers. The team had generated hair and cloth for *The Polar Express* without relying too heavily on dynamics simulations; but simulations were required for nearly all the characters in *Beowulf*. "Hair and cloth were a much bigger deal in this movie," said Sean Phillips, "and so we used a lot of simulations this time. The hairstyles of the women, in particular, would have been almost impossible to do four or five years ago. There were a lot of very complicated braids, and all of the hair had to move with the characters in just the right way." Angelina Jolie's character, for example, has a floor-length braid that whips and moves about her in serpentine fashion, as if it is a living entity. "The hair rigs are working so well now that it's easy to forget how difficult it was to get them up and running smoothly."

Flowing skirt-type garments and robes worn even by the male characters in the film translated to an extensive cloth simulation project, as well. "The period the film is set in and the costumes that people would wear back then lent themselves nicely to CG cloth," noted Phillips, "because there weren't a lot of pockets or zippers or any of those things that are traditionally difficult to do in CG. So we did a combination of modeled and simulated stuff on the costumes." To build costumes in CG, Imageworks used scan data of the actors in wardrobe, as well as actual patterns acquired from the costume designer. "There are two routes you can go with cloth simulation. You can build the garment draped over a character already, and then add simulation on top of that. Or you can build it from a pattern, just like a dressmaker does, so it hangs the way it would when you put it on the character. It's a less intuitive way to model it; but if you have access to the patterns, as we did in some cases, it works. We did it both ways, depending on the costume and the shot."



Danes recover after an attack by Grendel. In addition to creating photoreal characters, Imageworks generated many authentic looking environments inspired by aerial photography of picturesque Danish villages and terrains. Imageworks projected matte paintings onto 3D geometry for one-off environments, and constructed fully 3D environments for those seeing more screen time. Complex and extensive effects animation for smoke, fire, water, snow and blood effects created realistic interaction between the digital characters and their synthetic environments.

After cloth simulation, the effects animation team ran another simulation to create the look of chain mail worn by the film's warriors. "We had a whole chain mail system," said effects animation supervisor Theo Vandernoot, "which I had originally designed for Mr. Beaver on *The Lion, the Witch and the Wardrobe*. Every character that wore chain mail had to initially go through effects animation.

Animation would animate the characters, the cloth team would simulate a steel ‘cloth,’ and then we would re-simulate the links on top of that cloth to ensure they were all sitting and twisting and bending in the right way.”

In addition to synthetic actors, *Beowulf* featured fantastic creatures such as Grendel, whose design evolved from Doug Chiang’s original artwork. “I’m really happy with how Grendel turned out,” remarked Jerome Chen. “Bob Zemeckis described Grendel as ‘a creature wracked with pain and suffering from every deformity and skin disease known to man.’”

Character modeling supervisor Ed Taylor worked in Maya to modify a digitized scan of a Chiang maquette, which Dennis Bredow texture-painted. “Dennis was inspired by hundreds of pictures found on the web,” explained Grendel supervisor Brian Steiner, “mostly autopsy photos and pictures of car accident victims. Kevin Smith wrote RenderMan shaders to get the perfect shine to Grendel’s open sores.”

Though early renderings incorporated some of Crispin Glover’s facial features, the final look for Grendel bore little resemblance to the actor. Glover’s startling performance on the motion capture stage, however, was the driving force behind the character. “Crispin Glover was a great casting choice,” said Chen, “because he brought an incredible edge to that character. He did this horrible, primal screaming through the entire performance — literally screaming for days on end on the motion capture stage — because Grendel is all about being in pain.”

To sell the character’s scale in scenes in which he savagely attacks and dismembers Hrothgar’s thanes, Imageworks motion-captured the actor tearing apart half-size puppets. “Since Grendel is supposed to be 12 feet tall,” said Chen, “all of the humans in the scene are approximately half his size. So we made half-scale puppets with velcro attachments for Crispin to work with. He could grab one and pull off its arm or head, and we captured him ripping the puppets to pieces.”

To fully sell Grendel’s size, animators scaled up Glover’s motion capture performance, expanding it and slowing it down in some shots. Keyframe animation also helped to make Grendel’s deformities read on screen. “Crispin Glover had contorted his body and limped in his performance,” Kenn McDonald noted, “and we played up that limping and hunching in our animation. We also customized the motion capture data to mimic paralysis on one side of his face; and then we played that up even further in the animation.”

The only character to be entirely keyframe animated, without a motion capture-based performance, was the enormous dragon that *Beowulf* fights at the climax of the film. Imageworks built an



Surrounded by loyal thanes, Beowulf confers with King Hrothgar (Anthony Hopkins) on a beachhead. Flowing skirt-type garments and robes worn by all the film’s characters – male and female – translated to a major cloth simulation project. Imageworks built CG costumes using scan data of the actors in wardrobe, as well as patterns acquired from costume designer Gabriella Pescucci. To create the look of warriors clad in chain mail, the cloth team first simulated a steel ‘cloth,’ and then the effects animation team re-simulated links on top of that cloth to ensure they were twisting and bending appropriately.

extremely detailed animation rig for the dragon. Individual controls for each of the joints on the creature's bat-like wing allowed for complex flapping motion, while controls on the leathery membrane between the joints enabled animators to simulate a sense of turbulence as the creature flies at high speeds. "We tried to make the animation of the dragon as detailed as possible," remarked McDonald. "We were very fortunate to have animator Atsushi Sato on our team. He did a lot of the developmental animation on the dragon, figuring out how it should move and fly." Animators also had to suggest sentience in the dragon's performance, as he is not just a creature, but rather a man transformed into a dragon. "Bob wanted to see the dragon thinking, so we had to include in the dragon performance motivations behind what he was doing and reactions to what was happening. We had to make it look as if he was weighing options, rather than just reacting instinctively, like an animal would. It was a challenge coming up with moments where we could make that thought process read in the performance."

Beowulf's creatures and human characters alike exist in computer generated environments inspired by photography of picturesque Danish villages and countryside. Imageworks' matte painting department, headed by Steve Matson, projected matte paintings onto 3D geometry for one-off environments, such as a series of landscapes covered during the aerial dragon fight. Environments seeing more screen time, such as the interior of Hrothgar's hall, were generated fully in 3D by model supervisor Mark Krentz and his team and look development artists led by Francis Lui and Owen Demers. The only scene featuring a live-action environmental element was one in which *Beowulf* — as an aged king — confronts an invading army on a beach. "Looking for reference," said Jerome Chen, "we went down to Hermosa Beach and shot some waves with an HD camera. It looked so great, we decided to just put that HD footage into the film." For the invading army, Imageworks motion-captured a second-unit battle with about 40 separate choreographed bits of action, and then layered them together.

An extensive and highly diverse effects animation effort that included smoke, fire, different varieties of water, snow flurries, blood, mead and other effects tied all the digital characters to their environments. "On most films," noted Theo Vandernoot, "you have one trademark or signature effect, be it fire or water or some cool transformation or whatever. That



Hrothgar's queen, Wealthow (Robin Wright Penn) offers Beowulf treasure in thanks for his service and protection. While Imageworks had generated hair for The Polar Express without relying too heavily on dynamics simulations, such simulations were required for many of the characters in Beowulf to produce long, flowing tresses that moved in a believable fashion.



Beowulf's trusted second-in-command, Wiglaf (Brendan Gleeson). Highly customized facial animation rigs that

forms the core of your effects development, and then you have a few ancillary effects, as well. On this film, we did everything. We wrote our own in-house computational fluid dynamics solver for all types of liquid, for example. We tried some third-party stuff, but in the end we had the resources and the talent to write our own, which worked out much better. As part of that, we developed a blood system that we used for a number of shots. It was customized and modular so that the director could pick and choose which parts of the blood would be visible in shots.”

enabled Imageworks animators to re-create even tiny movements specific to each actor further ensured verisimilitude in the synthetic characters.

Imageworks also devised an oceanic water system, leveraging off the work that had been done on the company’s animated feature, *Surf’s Up*. In addition, Vandernoot wrote a program to simulate the specific qualities of the water in the cave that is home to Grendel and his mother. “That is a shader-based, textured water,” observed Vandernoot, “a pseudo-simulation. And then, inside that water cave are bioluminescent organisms. Vincent Seratella and I developed that. Whenever a character disturbed the water in the cave, this tool detected the velocity change in the water; and when there was an appreciable amount of acceleration, these little creatures would be born and start swirling around. That particle render was refracted through the water to create a sense of depth and a glowing presence below the surface.”

Fire was another frequently recurring animated effect. “We had two classes of fire in *Beowulf*,” noted Vandernoot. “We had the interactive fire for shots where someone falls into it or it is being disturbed by a wing moving, or the dragon shooting napalm — shots where the fire had to be customized. Then we had the fire library, which was set up by Vincent Seratella. That was a library of static torches, firepots, cauldrons and candles. The lighters and compositors could access this pre-canned sim and render it, which saved us an enormous amount of work.”



Mourning the slain Grendel, the monster’s vengeful mother (Angelina Jolie) lures Beowulf to her treasure-strewn cave dwelling. Imageworks effects animators employed a custom program to create a shader-based, textured pool of water in the cave. The team also simulated bioluminescent organisms that sparkle and glow when the pool water is disturbed, suggesting depth and a glowing presence below the surface by refracting that particle render through the water.

Overall, however, the extent of the work on *Beowulf* was daunting, requiring a division of the workload among five teams led by CG supervisors Theo Bialek, Max Bruce, Patrick Cohen, Brian Steiner and Jeff Stern. These production teams, each assigned approximately 150 shots, were tasked with gathering the assets from all the digital production pipelines and then compositing the rendered elements to create the final shots. “A hundred fifty shots doesn’t sound like a lot,” remarked Bialek, “but Bob likes long shots. I had a minute-long shot that swept across multiple environments and included fifty characters and a fire-breathing dragon. It took six weeks just to render the elements.”

In 2004, *The Polar Express*, in addition to its traditional theatrical release, enjoyed a limited stereoscopic Imax release. Many who saw both versions noted that, in 3D, *Polar Express* was a far

more affecting experience. Two years later, *Monster House* was also released for 3D as well as 2D exhibition; but, again, the 3D release was limited. *Beowulf* enjoyed the widest stereoscopic release of any CG film to date, with nearly 1,000 specially equipped theaters — Imax as well as digital 3D theaters — exhibiting the film throughout the United States.

Stereographer and 3D digital effects supervisor Rob Engle oversaw the creation of the stereoscopic version of *Beowulf*, as he had done for *The Polar Express* and *Monster House*. “What is happening when we make a stereoscopic film,” explained Engle, “is that we are creating two movies: one for the right eye and one for the left eye. Because all the assets for a CG movie, all the character animation and most of the environments, exist in a 3D virtual world, it is a fairly straightforward process to create a pair of cameras that can be used to capture the film in 3D.”

Starting with the animation as produced for the 2D version of the film, 3D previsualization lead Joanie Karnowski positioned a second virtual camera beside the main camera at a distance that approximates the six and a half centimeters between an average person’s eyes. “In reality,” said Engle, “we almost never position the second camera exactly six and a half centimeters from the main camera. Instead, we tune the separation in each shot to maximize the depth effect and to avoid harsh transitions at each cut. Our technology allows us to watch animation sequences from the film live, in stereoscopic 3D, so we can interactively adjust the separation between the cameras to achieve the most pleasing effect. The wider the distance between the stereo cameras in the virtual world, the deeper the stereo effect will be when projected in the end. We tune each shot to make sure we get the maximum depth effect without banging people over the head with it. We want audiences to have a comfortable and enjoyable 3D experience.” CG supervisors Layne Friedman and Grant Anderson oversaw completion of the final 3D shots, with technology support by 3D pipeline supervisor Alan Davidson.



A fire-spewing dragon was the only character in the film that was entirely keyframe animated. Imageworks built an extremely detailed animation rig for the character, which included individual controls for each of the joints on the creature’s bat-like wings and another set of controls for the leathery membrane in between. Animators incorporated a sense of intelligence in the dragon performance, artfully animating facial expressions to suggest conscious thought.

Whether in 2D or 3D, the 708 shots comprising *Beowulf* showcase the current state of performance capture technology, as well as the state of the art of computer generated movies. It is the latter in which Jerome Chen and his crew at Sony Picture Imageworks take their greatest pride. “Eventually,” Chen concluded, “no one will even be talking about the technology of doing movies this way — just as no one’s fixated on the latest circuitry in the Arriflex camera used on live-action films. Performance capture movies will be looked at the same way. No one will care about how it was done. That’s the change I see happening right now: a shift where audiences are starting to accept a performance capture movie as just another kind of movie, and a shift in directors’ perceptions, thinking of this as just another way to make a movie. More directors are beginning to look at it that way. Jim Cameron is using it for *Avatar*. I can easily imagine Peter Jackson or Steven Spielberg making such a film. For directors with a specific vision, this is the way to go.”

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Urban Legend

ARTICLE BY JODY DUNCAN

Every so often a piece of literature comes along that acts like kindling to the fire of the cinematic imagination, inspiring not one, but multiple film adaptations. Richard Matheson's 1954 novella, *I Am Legend*, is such a story. In a relatively few pages, Matheson painted a vivid portrait of loneliness and despair as his protagonist, Robert Neville, attempts to survive as the last man on earth, hunted at night by vampires — a condition wrought by a virus — and haunted by day by memories of a life and family lost.

The first film adaptation of the novella was aptly titled *The Last Man on Earth*, a 1964 Italian production starring Vincent Price. Charlton Heston played the Neville role in *The Omega Man*, a 1971 Warner Brothers release. After years of development and an aborted production that would have starred Arnold Schwarzenegger, with Ridley Scott directing, Warner Brothers finally succeeded in bringing yet another version of the story to the screen with the release of *I Am Legend*, directed by Constantine director Francis Lawrence and starring Will Smith.

The screenplay by Akiva Goldsman and Mark Protosevich took liberties with Matheson's novella, reconfiguring Neville's character from a plant worker to a brilliant scientist determined to find a cure for the virus that has infected and transformed humanity and left him, three years later, as the apparent sole survivor. The screenwriters also changed the story's setting from 1970s Los Angeles to present-day New York City. Most dramatically, the writers took the narrative out of the realm of vampire mythology and into that of purely biological catastrophe, presenting victims of the plague as savage, strong and high-metabolic creatures whose altered physiology has made them extremely sensitive to light.

Lawrence shot the film entirely in New York — exteriors on actual city streets, and interiors in armories in Brooklyn and Queens. With him throughout the shoot, and long before, was visual effects supervisor Janek Sirrs. "I came on when Francis was still doing preproduction development work," said Sirrs. "At that point, he was exploring ideas about what the abandoned city would look like and what the creatures might be. All we had were a few storyboarded sequences and a lot of conceptual artwork. Later, Proof came on and prevized virtually all the major sequences — the opening of the movie and all of the creature work. We continued doing previz well into the shoot, as well, which is what seems to happen these days."

Visual effects producer Mike Chambers came on the show five weeks into principal photography, which lasted from October 2006 until April 2007. The relatively long schedule was due, in part, to the logistical challenges of shooting on the streets of New York. "The city was very cooperative," said Sirrs. "They gave us a lot of help, and we were really appreciative of that; but, even so, it was a major headache to shoot on location there. There are a lot of people in New York, a lot of signs, a lot of traffic. To really create the look of an abandoned city, we would have had to lock down entire streets. They told us, 'Look, we can control a few blocks, but beyond that, it is what it is.' So we knew we were going to have to paint out everything that wasn't supposed to be there. That approach

allowed us to keep moving on the day and not worry about a huge lockdown; but it also meant that every exterior shot in the movie became a visual effects shot.”

Sirrs and Lawrence awarded the visual effects assignment to Sony Pictures Imageworks, with Jim Berney serving as visual effects supervisor. The film’s opening sequence, which establishes a deserted Manhattan going to seed after three years without human maintenance, was representative of the visual effects assignment as a whole. Dubbed the ‘joyride,’ the sequence has the camera following Neville in a Ford Mustang, racing through the lifeless streets as he chases a herd of deer. It was up to Imageworks to transform a vibrant Manhattan as it appeared in location plates into the desolate city gone to ruin. “The amount of ground we covered in the car was huge,” noted Sirrs. “We cleared out as much as we could on the day, which was a big challenge in itself; but then Imageworks had to matchmove all the areas that the car traveled through.”

To facilitate matchmoving and digital set extensions, all of the New York locations for this and other sequences were thoroughly photographed, surveyed and, in some cases, lidar-scanned. “Every location was at least surveyed,” said Sirrs, “just so we would have all the geometry there for basic matchmoving. We knew this was going to be a very difficult matchmoving job, because nearly the entire movie was shot handheld and anamorphic, which is the most difficult matchmoving scenario you can imagine.”

“Anamorphic is an absolutely beautiful cinemagraphic tool,” added digital effects supervisor David Smith, “but it provided us with quite a bit of challenge in being able to track and matchmove the shots because it results in so much distortion, which changes as you move a camera through a scene. All of that distortion had to be dealt with before we could properly track the plates. There were also a lot of smaller distortions within specific anamorphic lenses, and we had to deal with those aberrations, as well.” Imageworks worked with Yannix Technologies to develop a proprietary tracking tool for anamorphic that concurrently addressed the lens distortion and camera track issues.

After tracking and matchmoving, the Imageworks crew began the painstaking and laborious process of removing unwanted elements from the plates. “Even though they’d done a great job of locking down locations,” noted Jim Berney, “the plates had all kinds of things we didn’t want in them. There were streetlights, neon signs, bits of moving traffic and milling people in the backgrounds. Not only were there lights inside and outside of buildings, there were reflections from those lights on windows that had to be removed. We had to take all of these plates and paint out every single sign of life.”

To further sell the illusion of an abandoned city, digital elements had to be added to the plates, as well, such as accumulated dirt in gutters and around parked cars. “Three years have gone by,” said Berney, “and so things are faded and broken, and there is grime everywhere. It is still clearly Manhattan, but we had to age it and dirty it up. So we faded awnings and added bird poop to everything. We dirtied windows. We added piles of rubble around some of



Based on a novella by Richard Matheson and directed by Francis Lawrence, *I Am Legend* stars Will Smith as Robert Neville, the evident lone survivor of a viral plague that

the bigger buildings. We added sinkholes in the streets. Sometimes we added signs of looting, such as windows that were broken out. All of those details had to be added to these plates.” In the narrative, the viral plague that transforms the city’s population descends during the Christmas season. To support the story point, Imageworks lavished the plates with digital wreaths and other holiday decorations in the streets and in store windows.

has transformed the inhabitants of Manhattan into carnivorous, bloodthirsty, and supernaturally strong creatures. Visual effects supervisor Janek Sirrs engaged Sony Pictures Imageworks to create the ‘infected’ as 3D animated characters, and also charged the visual effects team with the painstaking task of removing all signs of life from production plates shot on location in New York City.

The most ubiquitous of the digital set dressing elements were weeds and grass growing out of cracks in the streets and sidewalks, and areas of overgrown foliage reclaiming the concrete-and-steel environment. Due to the huge volume of foliage work, animation effects supervisor David Stephens searched for as efficient a method as possible for producing digital plant life. “In the past,” said Stephens, “people have always talked about how laborious it was to get a natural-looking plant out of an L-system. So going into this, I was looking to do something that would be a lot more straightforward. I ended up developing a procedural algorithm that was vaguely L-systems-like, but could generate pretty much any kind of plant in fairly short order.” The approach involved procedurally generating a unique stalk for each instanced plant using a range of specified parameters for that plant type, and then attaching onto that structure modeled flowers, bulbs and leaves. “We could set it up so that a plant type had a lot of level-of-detail information available to it and could use higher or lower resolution modeled leaves or flowers, as needed. It really helped out in being able to go from hero foreground to low-rez background, all in one system, without having to build each type of plant at each resolution independently.”

Augmenting the procedurally generated modeled foliage system was a tile system used by Imageworks to produce grass-sprouting cracks in pavement and sidewalks and other signs of decay. To create the tiles, texture painters built up a library of broken-up pavement shapes, cracks, potholes, clutter, debris and patterns of grass. “Those tiles would be created in Maya,” explained Stephens, “and then the data would be passed off to the Houdini artists, who did the plant layout. A layout artist would go through and place these tiles into the 3D environment, creating a collage of broken-up pavement and weathering, and also providing the basis of the grass. We had a nice setup tool in Houdini for plant placement: the more artistic people could take what the grass system came in with and add to it by painting onto geometry; and the more technical people could just write procedural stuff. On top of that, they could specify variations of plants: ‘This area is 20 percent ragweed, 30 percent mugwort, 50 percent whatever.’ We could do everything from a broad-brush approach to customizing each individual plant, if needed.”

In addition to flora, Imageworks integrated digital fauna into the live-action environments. Scores of CG birds helped to keep shots alive, while other animals — such as the herd of deer Neville hunts in the opening sequence — supported the notion of an urban environment slowly returning to nature. “The city is reverting back to its natural state,” remarked



Berney, “and so there is wildlife all over. There are always bugs and birds in the backgrounds. There are deer. There are even lions that we see at one point — a lion, a lioness and their cubs.”

To produce the herd of deer, Imageworks created a basic deer model that could be textured with 15 different color patterns and fit with various sets of antlers. “We could either randomly generate which variations would get picked up or we could specify which features we wanted on specific deer,” explained David Smith. “Every deer, no matter how far it was from camera, was fully rendered with hair.” Fur generation was helped by the fact that Imageworks was in the process of converting from a NURBS-based to a polygon-based pipeline. “We weren’t quite there yet; but one thing we got working for this show was the ability to displace surfaces and grow hair off those displaced surfaces. That gave us a lot more flexibility in adding detail to our furry characters. How much detail there was in the fur would depend on the distance of the deer from camera.”

The same displacement technique was used on the CG lions, which are revealed in Times Square, where Neville continues his deer hunt on foot. “We get pretty close to the lions,” said Smith, “and that’s where we took advantage of being able to displace their surfaces. Except for the mane, they have a very short, laid-down quality to their hair, and we were able to make that detail come through.”



Production filmed near the Brooklyn Bridge – with the Manhattan and Williamsburg bridges in the background – for shots of the structures as they appear in Neville’s solitary world. In a flashback sequence, city bridges are blown up in an attempt to isolate the deadly virus to the island. Imageworks removed boats on the water and sections of bridge spans and supports. Artists then added twisted ironwork and crumbling concrete to suggest a post-demolition look.



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Due to production’s inability to shoot in Times Square, the 30-shot sequence in which Neville stalks the deer throughout the area required that Imageworks build virtually all of it as a 3D environment. “It would have been impossible to lock down Times Square tight enough to shoot there,” said Jim Berney, “but that meant we had to do all of this in CG — and I was pretty nervous about that at first. You see Neville walking through weeds, and then the camera tilts up to reveal that he is in the middle of Times Square, with a doe and a buck out in the distance and the lions in another area. All we had to start with was a shot of Will Smith walking on a piece of ground on stage, surrounded by blue. There was also a little ticket booth on stage, to give him something to interact with. We built everything else in CG.” Imageworks used lidar data from Times Square, gathered by Lidar Effects, to build its 3D environment. “The lidar stuff helped a lot. We built our models from that, and then projected photographs and matte-painted elements onto that geometry. Neville is walking and moving all around Times Square, so we had to build all of it.”

New Deal Studios, with Ian Hunter supervising and David Sanger producing, provided a miniature element of a crashed helicopter on a rooftop that Imageworks composited into the environment. “They wanted to get a good, archetypal image that showed that time had passed and that civilization had been wiped out,” said Hunter. “So they had this dolly move on a rooftop in New York, looking over the edge of the precipice, down into the street, and you see the deer running and Will Smith chasing it. Sony tracked the dolly move that they’d done in New York and gave us the tracking information so that we could use it to drive our motion control camera.”

Using the location survey data, New Deal built a digital version of the rooftop, and from that created a matching rooftop in 1/6 scale. “Using parts of the molds for a Jet Ranger helicopter that we’d built for *Terminator 3*,” said Hunter, “we were able to make another Jet Ranger helicopter. My crew chief, Scott Schneider, got a lot of reference on crashed helicopters; and he and modelmaker Adam Gelbart dressed the helicopter to make it look as if it had crashed, replacing a lot of body panels with crumpled metal pieces. Then we dressed that into the rooftop. We broke out all the window glass and covered it with mildew so it looked like it had been there a long time. Modelmaker Greg Boettcher built all these 1/6-scale plants that we dressed in and around the helicopter to make it look like they were grown in. Once we got the model built, we took it outside and lined it up to match the sun angle in the plate, and we shot it with our motion control camera. We shot it at 48 frames per second, and used a fan to blow the plants around just to give it a little life.”

Through a series of expository scenes, the audience learns how Neville’s life has been structured for the past three years: by night, barricaded inside his brownstone house, safe from the roaming infected creatures, conducting cure experiments in his basement laboratory; by day, hunting for

food, tending a farm in Central Park, and broadcasting from a pier — this last a ritual he performs in hopes of making contact with other survivors.

Lab scenes featured infected rats, and one healthy specimen, inside glass cages. The rats' infected look and behaviors had marked them as CG creatures from the beginning. "The infected rats obviously had to be CG because they had to do very non-rat behaviors," said Janek Sirrs. "We wanted rats that were extremely aggressive, biting and slamming themselves against their cages — none of which, of course, real rats do. That, in combination with their having to look sick, meant that they had to be digital."

Developing behaviors for the rats was a task that went to animation director David Schaub, who came on the show in May 2007, after animation supervisor Marco Marengi had laid the groundwork. "The rats were really tricky," observed Schaub. "The director wanted something very scary out of them; and we tried many, many different things before we found a behavior that worked. We tried having them lash out and claw at the glass of their cages every time Neville walked by; but that looked like they were just desperate to get out. They looked kind of pitiful and sympathetic, no matter how hard we made them scratch or bite. Then we tried having them slam against the glass with their bodies, over and over — but that just looked comical. What ended up working was having them behave in a bit more calculated a way. They rear back, like a cat, hissing and quivering and shaking, and then they slam against the glass and bite at it. That seemed to work."

Imageworks animators had a live rat in-studio to act as reference for the healthy CG rat, but the rodent was far too sedate for their purposes. "That rat didn't do much," Schaub recalled, "so we wound up using my neighbor's hamster as reference, instead. A hamster has a much higher metabolism and is much more active than a rat."

On his daily rounds, Neville spots another deer and goes in pursuit of it, a chase that leads him to a residence where many plague victims lie sleeping. The design and execution of the creatures — alternately designated as 'dark seekers' or 'the infected' — became the show's primary visual effects challenge, even though, originally, the characters were going to be realized mainly through live-action performers wearing practical prosthetic makeups. "We were planning to shoot them with actors in makeup," recalled Janek Sirrs, "but there was always a certain category of creature shots that was going to be done digitally, such as crowd scenes and stunt double type of work. That was always in the cards."

Not long into principal photography, the role of computer animation in realizing the characters grew considerably. "We were part of the way through



The infected creatures are led by an alpha male. Initially, the infected were going to be portrayed by performers in prosthetic makeups, with only the most strenuous action

when we decided to make them all digital,” explained Sirrs. “There were two main reasons for that. For one thing, we’d been fast-tracked into production, so we hadn’t had a normal preproduction time to develop what the creatures should be — what they would look like, how they would behave, all those things that, ideally, you would spend a lot of time researching beforehand. As we got closer to having to shoot creature scenes, the design was being scaled back more and more so that we wouldn’t have to spend so much time on the set with performers in prosthetics. And, in doing so, we realized at a certain point that we were curtailing the design completely. The other big eye-opener was when we got to shooting a big action scene in Washington Square Park at night. We were out there on location, with a bunch of people with very little clothing on running through the park, and we clearly saw that it wasn’t working. We found that we couldn’t have people run through a park in the dark, over obstacles, in the really high-energy way we wanted, without risking life and limb.”

“These were supposed to be very athletic characters who could jump really high and bounce off walls and stuff like that,” Jim Berney elaborated. “The production had cast athletes and dancers, but to really get them to run breakneck across this park with absolutely no care for their own safety just wasn’t possible.” The location shoot revealed some cosmetic problems with the makeups, as well. “Because these characters are supposed to be very sensitive to light, they were fairly light in color, covered in a kind of white ash. But out in the park at night, in the moonlight, they tended to glow on film. So there was a bit of an aesthetics problem, as well.”

The infected creatures are led by an alpha male. Initially, the filmmakers opted to realize all of the creature shots via 3D animation when it became clear that even skilled dancers, athletes and stunt performers could not execute behaviors with the speed and agility Lawrence envisioned. Freed from the limitations of the prosthetic makeup approach, Sirrs and Lawrence engaged Patrick Tatopoulos to design a new look for the alpha male and female, which became the basis of all of the infected characters.

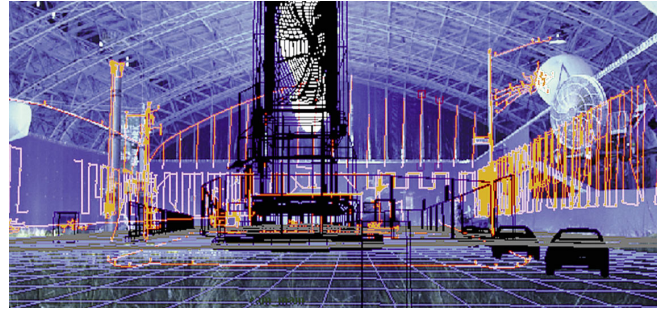


After establishing an empty Manhattan, the film’s opening sequence follows Neville as he stalks a deer in Times Square, now overgrown with grass. Unable to film in the busy intersection, production shot Will Smith on a bluescreen stage that was empty save a small ticket booth and an expanse of grass affixed to the stage floor. Using lidar scans, Imageworks created the entire Times Square area as a 3D environment, building models and then projecting photographs and matte-painted elements onto that geometry.

In the end, Lawrence and Sirrs decided to treat the Washington Square Park scene as a plate shoot, gather the necessary material, and then add digital infected creatures in post. Eventually, they agreed that if action scenes such as this one were going to be CG, better to make all the creatures throughout the movie CG than to have some makeups and some digital. “In making that decision, of course,” stated Sirrs, “we also gained flexibility as to what they could look like and how they could behave. Going digital opened up a lot of possibilities for us; and it gave us the time to explore those possibilities.”

With that decision, Sony Pictures Imageworks — originally assigned about 400 shots involving the city environments and background digital doubles — suddenly had a shot count of 800 that included fully animated, photoreal 3D creatures. The production plan was altered, as well, with infected performers donning gray spandex suits and tracking markers, rather than prosthetics, so that they could be motion captured on the set as they performed their scenes. The motion capture provided a basis of movement for infected animation and, more significantly, gave Will Smith tangible characters with which to interact in scenes. “We wanted the infected characters to be there for framing and performance and to help all of us understand what was going on in the scene,” Sirrs commented. “It meant a lot of paint-out and removal work after the fact; but the benefits were tremendous, and they really show. Will Smith was able to actually interact with the creatures because they were right there, breathing in his face. It allowed Francis to make better framing choices. Essentially, any time we had that kind of creature work, we were motion capturing. The only scenes we didn’t motion capture were the huge crowd scenes, because there would have been no point in trying to do motion capture for those.”

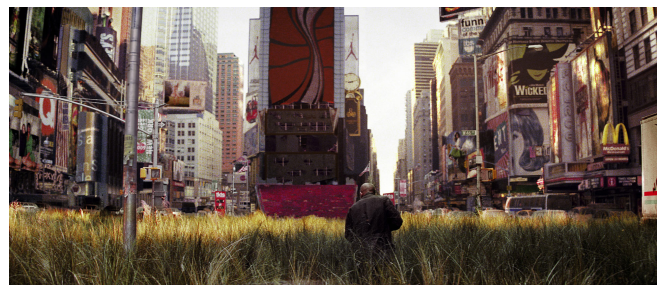
Back at Imageworks, the team dove into the task of creating photorealistic CG infected creatures within a limited time frame. Asked what he would need in order to meet that demand, Jim Berney answered, ‘a



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locked design and a sculpt.’ Both were provided by Tatopoulos Design Studios, which designed an alpha male and alpha female that served as the basis for all the infected. “In designing these characters,” stated Patrick Tatopoulos, “we were looking for things we could do to show that they had been

bluescreen stage that was empty save a small ticket booth and an expanse of grass affixed to the stage floor. Using lidar scans, Imageworks created the entire Times Square area as a 3D environment, building models and then projecting photographs and matte-painted elements onto that geometry.

human beings, but were now much more like creatures. For example, we made the characters very lean and tight, as if their entire bodies were in a cramp. Every connection between the limbs was tight, which created a very energized look to the creatures. We also extended their forearms and legs, which made them look very elegant. We extended their necks and gave them very long fingers, but no nails. The waist, too, was proportioned much smaller than the normal human waist would be.”

Once everyone had agreed on a design, Tatopoulos’ studio created quarter-scale models of the alpha male and female, as well as life-sized facial sculptures. “Glen Hanz, who has worked with me for years, sculpted those,” said Tatopoulos, “and that gave us something in 3D to look at. For the female, we did a face cast of the actress who was going to play her on the set and worked from that cast. Even though she would never appear in the final film, her features were very pleasing to Francis; and so, we wanted to incorporate them into the alpha female character.”

Gentle Giant Studios scanned the sculptures and Imageworks began building its hero infected male and female from those scans, with CG supervisor John Monos handling the development of the creatures’ photoreal look. The final computer models were exceptionally complex, consisting of multiple layers of physiology. “There was a layer of bone,” explained Jim Berney, “a muscle layer, a vein layer, and then the skin layer, which contained the capillaries and had a yellow, jaundiced look. Their skin was translucent, almost transparent, so you could see all their capillaries and veins. We did that with subsurface scattering, but it was a subtle effect. When you looked at the character, it still looked photoreal, like a real human. Francis always wanted to maintain a high level of realism. He did not want anything hyper-real. He never wanted to go into the realm of fantasy.” In addition to translucent skin, the infected creatures featured completely hairless heads and bodies — with the exception of the alpha female. To make that character look a bit more appealing and feminine, Imageworks cheated in faint eyebrows and eyelashes on her face.

The infected designs continued to be tweaked well into shot production. “The director really wanted these characters to make an emotional impact,” said David Schaub. “He wanted them to be really scary; and to get that was an evolving process. Making the creatures scary didn’t just depend on their design. It was the combination of the design and the animation and the lighting that made it work. So, well into animation, we continued to make design changes. We would go down a certain path in animation, and then we’d discover that we needed to make design changes to get that emotional, scary factor. Of course, it’s difficult to make those design changes when you’re that far into animation; and so we had to develop some work-arounds. We did sculptures on the fly, shot by shot, to incorporate the design changes.”

To create a full range of infected characters, Imageworks scanned nine stunt people, supplementing the original scans of the alpha male and alpha female performers. “We took those nine,” said Jim Berney, “as well as the two alphas, and from those eleven scans we built additional characters. We remodeled heads, deformed the shapes to create different body types, and mixed and matched costumes. Michael Kaplan, the costume designer, designed roughly 40 different costumes for the infected, and we built all of them. That process of mixing and matching heads, bodies and costumes gave us another 43 characters, all of which were completely heroed out.”

“Of the 43 hero characters,” added David Smith, “each fit one of three body types for the males, and one of three body types for the females. We ended up naming them ‘A’ names for the A body type, ‘B’ names for the B body type, and ‘C’ names for the C body type. So we’d have a Bob or a Carl, and we could spot them in scenes. ‘Hey, there’s Carl over in the corner!’ That was a way to have fun with it, while also keeping track of the mix of body types in a scene.” Employing the limited set of body type topologies allowed for maximized reuse and variation of models, textures and cloth simulations.

For shots in which the characters were relatively sedate or moving like a normal human being, Imageworks often was able to use the motion capture as it was, without a substantial amount of keyframe enhancement. Dynamic action sequences, however, or those in which the infected had to deliver an emotional performance, required the artistry and eye of the animator.

“There were a lot of character and movement studies that were done early on by Marco Marengi and his crew,” commented David Schaub. “We tried insect-like behavior, where the creatures scurried like cockroaches. We also did animation tests where the creatures moved like gibbons. We tried quadrupedal locomotion, as well. All of that played into what we ultimately added to the performance capture. We definitely amped everything up to make the performances more powerful. The creatures had to be scary and violent and fast and savage. So when they slam themselves up against walls, for example, we took what was in the motion capture and pushed it over the top. And yet, they still had to look like real characters doing real things. We went down the path of doing things humans couldn’t really do; but as soon as we went there, it started to look caricatured. They needed to be fast, but the weight still had to be retained. If you just speed things up, it starts looking like Keystone Kops. The hardest thing in animation is to get the weight and physics right in very dynamic action scenes — and we had a lot of those types of scenes in this movie.”



A renowned scientist in his former life, Neville captures the alpha female creature and takes her back to his basement laboratory where he conducts experiments in search of a cure for the viral infection. To make the alpha female look more appealing, Imageworks cheated the creature design – which called for them to be completely hairless – and gave the character faint eyebrows and eyelashes. Like that for the alpha male, the female computer model was based on a scan of a Tatopoulos Studios sculpt. Final infected models featured multiple layers of physiology, including bone structure, muscles and a system of veins and capillaries, all covered in a pale, transparent skin.

Secondary animation, such as the infected's hyperventilated breathing, added to the horrific quality of the characters. "The infected have a super-high metabolism," explained Berney, "so they are always hyperventilating, and you can often see their veins pulsing. They also have particle sweat that moves down their foreheads a lot of the time."

"We had the base performance," said David Schaub, "and then we had this additional layer of breathing that went on top of that. The breathing motion isn't just lungs inflating — the whole body gets involved in the breathing process. The spine joints are rotated and counter-rotated; and, as a result, there is a delicate balance and counter-balance that goes on throughout the entire body. The breathing was a good way to keep things alive in the face, as well, which is one of the problems of a CG character. It can so easily become stiff and plastic looking if you don't keep things alive. When they are breathing heavily, you see a subtle puffing of the cheeks, along with nostril flares, movement of the muscles down the neck, and movement in the veins. All of that tied together with the body breathing, and added to the realism of the characters."



Infected canines that attack Neville during his daily rounds in the city had the same transparent, hairless and leanmuscle look as their human counterparts. On the set, crude props stood in for the dogs for lighting and framing purposes. In postproduction, Imageworks integrated its computer animated infected dogs into the scene, resculpting canine heads shot-to-shot to maintain consistency in their look. Animated 3D dogs – including a CG version of Neville's healthy Alsatian, Sam – enabled the visual effects team to create an unusually vicious and authentic dog fight.

Narrowly escaping the creatures at their nesting place, Neville later returns to the house, captures the alpha female and takes her back to his laboratory for study. "He examines the creature on a table," said Janek Sirrs, "while she is in repose. And then she wakes up at a certain point and thrashes around on the table. One thing we tried to do with the digital creatures was amp up everything beyond what a real person could do. For this thrashing scene, even a stunt person could only thrash about so much without harming herself; whereas, with a CG creature, we could make it much more violent and painful."

The following day, Neville is snared in a trap orchestrated by the infected creatures at Grand Central Station. The city agreed to close an area surrounding the transportation hub during specific early-morning hours so that production could shoot the sequence. "We filmed at Grand Central Station for a couple of weeks," Sirrs recalled. "In the movie, it looks like it is totally deserted; but, of course, while we were filming there was a lot of traffic below, along with the sound of horns and sirens — it didn't feel abandoned at all."

Trapped, Neville is attacked by three infected dogs released by the alpha male. Like the lab rats, the infected dogs had been slated as CG characters from the beginning, due to their transparent, hairless look and the violence of their behaviors. On the set, crude dog props stood in for the canines for lighting and framing purposes. In post, Imageworks integrated computer animated infected dogs into the scene. "The dogs have the same infected look," said Berney. "They have zero

body fat, and slightly transparent skin. They salivate and they have hemorrhagic gums, so when they open and extend their jaws, strings of spittle snap off.”

Shots of Neville’s Alsatian, Sam, fighting the infected dogs required a digital double for the healthy canine, as well. “We wanted it to be a very vicious dog fight,” said Janek Sirrs. “Usually a dog fight in a film is full of tricks: they never really show the dogs making contact; they use strings to pull back the dogs’ gums so they look as if they are baring their teeth; they circle the camera around. By going with all CG dogs, we could make it an extremely vicious dog fight, with a lot of physical contact.”

“For the dog fight,” elaborated David Schaub, “we tried a lot of different behaviors, just as we had for the lab rats, just trying to find something scary. The director had responded well to reference footage of hyenas, and so we went down that path for a while; but as we got into it, it was clear that it wasn’t going to work. Hyenas move really fast and they are very light on their feet, which is a curse in animation. As soon as you make anything look light, it doesn’t work. So we abandoned that and decided to go heavier, beefier and bigger with the dogs. The dogs had this body mass that would shake and jiggle with their weight.” One of the challenges of the sequence was that the look of the infected dogs — which resembled Dobermans — changed dramatically from one camera angle to another. “The lenses would make their snouts look shorter when they were close up, and they didn’t look like the same dogs. So, shot to shot, we had to go in and sculpt the faces to make them look like they were on model.”



When Sam dies from wounds suffered in the fight, an enraged Neville lures the infected onto a pier, and – in a scene dubbed the ‘demolition derby’ – mows them down in an SUV. For scenes featuring few infected creatures, production shot performers in motion capture suits, which gave Will Smith a live character to act against and helped the filmmakers in choreographing action, camera moves and framing. Since the ‘demolition derby’ featured too many infected and too much perilous interaction with the vehicle, Imageworks realized the sequence entirely in post, starting only with a bluescreen element of the SUV racing around an empty stage.

Sam eventually dies from wounds suffered in the dog fight. With his only companion gone, an enraged Neville attempts a mass killing of the infected by mowing them over with an SUV on the pier, in a sequence dubbed ‘the demolition derby.’ “He essentially sets a trap for the creatures on this pier,” said Janek Sirrs, “by putting a dummy out there as bait. And then he tries to mow them down and kill them. It’s a big action scene with the car and about fifty of the creatures. We boarded it, prevized it, and then shot it bluescreen on stage — but it was the type of scene that couldn’t really come together until post. Unlike closeup scenes with the creatures, where we had an actor there performing, we didn’t have any stand-ins for the creatures in this scene. All we had was this SUV driving around on the stage. The scene didn’t come together at all until we started adding in the animated creatures.”

The barge pier setting of the demolition derby was also featured in an evacuation flashback sequence — one of several flashbacks Neville experiences throughout the film. In the flashback, he recalls the frantic drive through the streets as he attempts to deliver his wife and child safely to the evacuation site and aboard a military helicopter. “The driving scene was shot on a greenscreen stage,” said Berney, “so we had to shoot plates in Manhattan for the backgrounds. We had to add a

lot of Christmas decorations to that, as well, to really sell the idea that this was happening at Christmas time.”

Wide shots of the evacuation scene were shot at New York’s waterfront, the most logistically challenging of all the locations. “The production closed off a section of the South Street Seaport area in Manhattan,” recalled Mike Chambers, “near the base of the Brooklyn Bridge, and there were about 14 governmental agencies involved: the New York mayor’s office, NYPD, NYFD, the Coast Guard, the Department of Transportation, the Department of Defense, the Army Corps of Engineers.” The FAA had to be involved, as well, because the scene required multiple helicopters to take off and land on the pier. “We also had more than 1,000 extras there. On top of everything else, it was extremely cold, because we were filming this in January, at night, in temperatures that dropped as low as 10 degrees. Shooting that evacuation scene was a very big deal.”

Imageworks extended the scene beyond the locked-down location area, adding many evacuation barges docked along the coastline, crowd extensions, and flying helicopters. “There’s a big reveal of a bunch of helicopters doing a mass exodus from Manhattan,” Jim Berney observed. “The shot starts by going up and over the FDR Drive and then continuing up to the Brooklyn Bridge and a Blackhawk helicopter taking off. But we couldn’t touch the FDR. So we did a Spydercam shot up to near the FDR; then cut, ran over to the other side with a crane, and shot a lock-off with the helicopter and the Brooklyn Bridge. Then we fabricated an element in between to bridge those two shots. We had to build the FDR, build the 3D Brooklyn Bridge, and then shoot military people on greenscreen and add them in. The far back end was a matte painting.” Two of the helicopters — including the one carrying Neville’s family — collide in the chaos. Imageworks’ effects animation team employed rigid body dynamics to create the collision, and then added fire and smoke effects.



In one of the film’s flashback sequences, the military blows up the Brooklyn Bridge to prevent unauthorized evacuation of the city. Rather than a surreal, cinematic look, Lawrence wanted the explosions to appear as gritty and realistic as possible. Imageworks kept that brief in mind as artists generated CG fire, smoke, dust and debris falling from the collapsing bridge. Imageworks went through a long period of research and development for the demolition, which was ultimately executed in Houdini using a combination of rigid body dynamics and procedural techniques.

A subsequent flashback sequence features six shots of the military blowing up the Brooklyn, George Washington and Manhattan bridges to isolate the virus to the island and prevent its spread. “We are standing under the Brooklyn Bridge as jets come over and start blowing up the bridges,” stated Berney, “one after another, very quickly. They blow up, and then they collapse, right in your face. Francis wanted it to look as real as possible — not with a lot of huge fireballs and slow-motion stuff. In addition to the exploding bridges there was CG fire, smoke, dust and debris falling from the bridge. There were also digital splashes as debris fell into the water.”

The bridge destruction sequence focuses on the Brooklyn Bridge. “We see the other bridges collapsing in the background,” said David Stephens, “but the Brooklyn Bridge is the one we see blow up in the foreground. We went through a very long period of R&D for that. It was all done in Houdini, and was a combination of rigid body dynamics and procedural techniques. We created a

low-rez representation of the bridge that was broken up into the basic chunks that we wanted it to decompose into. We ran rigid body simulations on that; and then that data was used to drive a series of procedural filters. We deformed the high-rez bridge to match the rigid body simulation and also contorted and tortured the metal to make it fray apart. This combination of dynamics driving procedural stuff was a very effective system.”

Back in the present, Neville is overcome by the infected during the demolition derby, and then rescued by a woman, Anna (Alice Braga), who has come to the pier with a young boy in response to Neville’s broadcasts. At his brownstone, Neville shows Anna the alpha female creature that, through his ministrations, has begun to show signs of healing. “For this scene,” said David Schaub, “they wanted the alpha female to look beautiful — or, at least, the equivalent of beautiful for an infected character. So that required some redesign. We had to resculpt the face of the model somewhat to make her look more pleasing.”



The film climaxes with hordes of infected storming Neville’s brownstone, intent on retrieving the alpha female. To reach Neville’s door, the infected run a gauntlet of exploding bombs he has set to create a protective perimeter. Imageworks layered in 2D fire explosions augmented with a dust shockwave and simulated, interactive smoke effects. Imageworks built up the storming crowd of infected in layers, with combinations of 43 hero characters in the foreground and more generic Massive characters in the background. Animators created hero crowd performance using motion capture data or keyframe animation cycles.

Neville’s abduction of the alpha female is the catalyst for a climactic battle sequence in which an army of infected storm his house at night. With as many as 150 creatures in frame at any given time, the end battle featured by far the largest number of animated characters seen in the film. Imageworks built up the storming crowd of infected in layers, with hero characters in the foregrounds and Massive characters filling out the backgrounds. Animators created hero crowd performance using motion capture or keyframe animation cycles. “We had animation cycles that they had captured or animated,” said David Smith, “and they were able to repeat those cycles and modify them slightly so that the characters swarmed together, as a group. We created some really nice tests with up to thirty or forty characters in frame. When it went beyond that, we used Massive. We had been wanting to integrate Massive into the facility for some time, and so we took advantage of this opportunity to do that. We spent a fair amount of time in the beginning, setting it up and integrating it into our pipeline. We were still exploring the movements of the characters, and we had a lot of different motions that we were trying to get into the brain of Massive. Another concern was bringing the Massive characters into our lighting package and making sure they all looked the same. But, in the end, we were very successful in doing that.”

Neville’s first line of defense against the invading infected is a row of floodlights he has erected in Washington Square Park, across from his house. When he turns the lamps on, the bright light causes the creatures’ skin to burn and char. “Their skin peels back and burns away to the muscle,” said Jim Berney. “So when these lights come on, they all hit the ground, writhing in pain, their skin smoking. Our effects team created very detailed and interesting burn and smoke effects for those shots.”

“You see the burn effect in other shots in the movie,” observed David Stephens, “but this was the one occasion where we had to see it on many, many characters simultaneously. Because we had to do it on this industrial scale, we had to find a way to streamline the process. What we came up with was a combination of shader work and effects animation, using some fairly esoteric features in RenderMan. We were able to light the characters as we normally would for a 3D scene, but then we could extract the lighting information as particle data and run it through Houdini for a variety of purposes. The processed data was then sent back to the shader folks to drive the skin burning effect, and also to the effects folks for the smoke simulation.”

The infected smash the floodlights and dash across the park, which Neville has booby-trapped with bombs. “The bombs start exploding,” stated Berney, “and it’s as if you are right there in it. The camera is moving through these explosions and this chaos, with bodies all around. We shot 2D fire explosions for that, and then augmented it with a dust shockwave. There’s a flash, and then heaps of smoke and raining, fiery ash falling down. As the creatures emerge through the smoke and come running across camera, you see that some of them have caught fire. There are loads of effects in that sequence.”

Imageworks supplemented practical pyrotechnics on set with additional smoke, sparks and debris. “We had a lot of fluid sims and volumetrics to assist with the practical effects,” stated David Stephens. “Smoke simulations created interaction, so as the characters ran through it, it would be disturbed and roll around a bit.”

Some of the infected make their way into the house, and Neville fights off the alpha male as Anna and the boy run to the lab for safety. The choreographed fight between Will Smith and the gray-suited performer was motion captured on set. “They managed to get some motion capture from that,” said David Schaub, “but a lot of it had to be reconstructed because most of the markers got lost in the flurry of the fight. It became a matter of roto-mating our character back into the fight scene. We had to paint out the motion captured performer and replace him with our CG character.”

About 30 of the infected reach Neville’s glass-enclosed lab, where they begin viciously attacking the walls, trying to get in — much as the lab rats had attacked their glass cages in an earlier scene. “The infected come running in,” explained Berney, “and they are all sweating, trying to bash in this transparent wall. For those closeups, we made sure to lay in characters that wouldn’t be recognizable from previous scenes. Also, because of the exertion, they all have particle sweat dripping down their faces.”

Once the infected, including the alpha male, have made it inside the laboratory, it becomes clear that their intention is to retrieve the alpha female — nothing more. “At that point,” noted Janek Sirrs, “Neville’s — and the audience’s — assumptions about the nature of these creatures are shown to be incorrect. We see that they have actually retained some of their humanity. There is a very important moment between the alpha male and Neville; and this moment really pinpoints why we wanted an actor on the set to play the creature. We filmed Dash Mihok, the alpha male actor, on the set, and extracted some facial capture, but it was minimal. It was more important to have the actor there so that he and Will Smith could play off each other. That was the genuine type of performance we wanted to emulate in the CG character, because it was far better than anything we could have come up with after the fact. Afterward, we went in and carefully matched all the subtle

motions of the face, all the nuances. It was very exacting work to match that performance so carefully, but Imageworks did a great job. We literally put the animation up side-by-side with the original performance to make sure we hadn't missed anything."

"There was a lot of subtlety that had to come through in that moment," said David Schaub. "Then, when Neville finally turns the alpha female over to the alpha male, there is this little love moment between the two of them. That was another very tricky bit of business to get just right."

Having secured what they came for — the alpha female — the infected spare Neville's life, and he, Anna and the boy leave Manhattan, hoping to find other survivors in the outside world. The last shot follows their car traveling over what is left of the George Washington Bridge — a shot comprised of aerial photography and digital environmental elements.

Imageworks delivered its final shots in early November, slightly more than a month prior to the film's theatrical release. "Once we made the decision to do the creatures as CG," said Mike Chambers, "we all understood that it would mean everything would go to the last minute. We needed every bit of time we could get, because the creatures and the environments had to look absolutely real. *I Am Legend* was a great opportunity to produce both visually powerful 'invisible' environmental effects and cutting-edge photoreal 3D creature animation — made possible only by the incredibly hard work of a talented, world-class crew."

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Northern Lights

Article By Joe Fordham

The Golden Compass marked New Line Cinema's first return to large-scale fantasy filmmaking since Peter Jackson's adaptation of J.R.R. Tolkien's *The Lord of the Rings*. Similarly epic in scope, the opening volume of Philip Pullman's trilogy, *His Dark Materials*, was a brave choice for the studio, not only for the logistical challenges it posed, but also for its explorations of alternate realities and religious ideology.

The story follows a preteen girl named Lyra Belacqua (Dakota Blue Richards), resident of Jordan College in a strangely futuristic Jules-Vernean England. Lyra journeys to the North Pole in search of her relative, Lord Asriel (Daniel Craig), a heretical scientist who has discovered an elementary particle he believes to be a link to a parallel universe. Lyra's journey pits her against a rival explorer, the beguiling Mrs. Coulter (Nicole Kidman), talking spirit animals, a society of warrior bears and a coven of witches.

To tackle the adaptation, the studio assigned writer-director Chris Weitz, a filmmaker making his first foray into the fantasy genre after experience with comedies, including *American Pie* and *About a Boy*. Weitz developed the project in England, then, after nearly a year's work, stepped down, daunted by the technical challenge. Director Anand Tucker took over, working with production designer Dennis Gassner and visual effects supervisor Nick Davis to take the film to greenlight. Michael L. Fink then stepped in to supervise visual effects for the production with visual effects producer Susan MacLeod. Ultimately, Tucker departed and Weitz returned to tame what had become an unwieldy 150-page screenplay. "The script was considerably more elaborate back then," Fink recalled. "We had quite a few storyboards, some done by Chris in 2005, and all of Dennis Gassner's conceptual art. Dennis and I have been friends for 27 years, since we worked on Francis Coppola's *One From the Heart*, and we have remained friends since then; so we had a pretty open way of communicating, and we had a lot of back and forth regarding the film's design, incorporating ideas designed for both Chris and Anand."

Based on early location reconnaissance, the filmmakers planned to shoot scenes representing the Arctic Circle in the archipelago of Svalbard, a location named in Pullman's book, located midway between Norway and the North Pole. "We first planned to shoot in England from late summer to early spring," Fink explained. "As soon as there was enough light in the sky, we'd go up to Svalbard and shoot plates and then return for a few weeks with a small unit and the young girl who played Lyra. That was the idea when the film was going to be released in 2008." When the studio advanced the release date to late 2007, visual effects sprang into action. "We had to shoot in Svalbard immediately. This was April; and by the middle of May, the sun was up 24 hours a day. When it was sunny, the temperature averaged between zero and five degrees Celsius, the sea ice was melting and all the snow was starting to look like soft ice cream!"

Fink scouted Svalbard with associate visual effects supervisor Eric Pascarelli and, based only on script pages, shot extensive ground-level digital still photography and Panavision Genesis helicopter

motion picture footage of landscapes and environments. The helicopter unit amassed 17 hours of Genesis material, taking advantage of the high definition format's image clarity and efficient data storage. The textures then became photogrammetry material for visual effects vendors who digitally reconstructed environments to dramatic needs.

The production shot all of Lyra's Arctic scenes on greenscreen soundstage sets at Shepperton Studios, then extended them digitally. For exteriors in the fictional Jordan College, the production filmed at Oxford University. Locations in London served as the basis for a heavily modified capital city, embellished by Shepperton sets and digital extensions.

One of the most challenging aspects of the adaptation involved the creation of an omnipresent talking-animal population of 'dæmons' — magical familiars that represented their human's innermost thoughts and feelings. "There was no way we were going to create all the dæmons with real animals," asserted Mike Fink. "Dæmons had to have a direct link to their humans, and my goal from the outset was that there should never be a wrong note between the two. I felt if we lost that connection, then we'd lose our audience, because that relationship was so important to the story. Not only that, our 11-year-old star was in nearly every scene, and British child labor laws meant she was only available to us for six hours of filming a day. We would never have been able to sit around waiting for an animal to perform; we had to shoot and move on. So it seemed a no-brainer that dæmons should be digital."

The commitment to creating dæmon characters digitally placed a burden on postproduction, so the filmmakers explored ways to optimize dæmon appearances. "The studio asked us to consider making dæmons invisible and have them appear occasionally out of the shadows," related Fink. "Both Chris and Anand felt that dæmons should look photoreal. We wanted dæmons to have certain recognizable traits — dæmon eyes, for instance, reflect their human's eye color — but we all felt very strongly that these creatures should look like real animals, and we should not anthropomorphize them. Very early on, I suggested that we rig CG dæmon faces with anatomically correct animal muscles. A lot of previous talking-animal films have added controls in facial animation rigs that were more human than animal. I really didn't want to do that, and I pitched strongly that we should rig dæmons to move like real animals, so their expressiveness would be animalistic."



*To portray the parallel worlds and magical creatures surrounding Lyra Belacqua (Dakota Blue Richards), the young girl at the heart of novelist Philip Pullman's fantasy *The Golden Compass*, New Line Cinema and writer/director Chris Weitz filmed on locations in Norway,*

Switzerland and England, and at Shepperton Studios. Visual effects supervisor Michael L. Fink and visual effects producer Susan MacLeod oversaw the creation of environments and digital creatures using vendors in London and Los Angeles led by Rhythm & Hues. Rainmaker generated the projection using a greenscreen element of an explorer with a canine companion, and aurora effects created at Rhythm & Hues. Rainmaker added background imagery into greenscreen stage photography of Lyra in an arctic camp. Rhythm & Hues digital fluid simulations projected onto ribbon geometry that flowed and shimmered. Rainmaker layered the aurora into a digital night sky – against scenic textures of mountains, clouds and ice – and animated particle animation ‘Dust’ to simulate a celestial phenomenon emanating from the aurora.



Lyra comforts Pantalaimon, her shape-shifting dæmon companion, after a traumatic attack. Rhythm & Hues digitally generated ‘Pan’ and other lead dæmons – while Cinesite and Tippett Studio generated ancillary dæmons – depicting photorealistic, talking animals that, in Pullman’s poetic language, represented the external embodiment of the human soul.

Neal Scanlan Studio sculpted clay maquettes for animated characters, including Lyra's shape-shifting dæmon, Pantalaimon (voiced by Freddie Highmore), Mrs. Coulter's mute golden monkey, and Lord Asriel's snow leopard, Stelmaria, (voiced by Kristin Scott Thomas). Scanlan's team also created on-set reference 'stuffy' dæmons to assist lighting, actor eye-lines and blocking. Gentle Giant scanned the maquettes, then Rhythm & Hues generated hero dæmons while Cinesite handled the majority of ancillary dæmons.

To help ground performances in nature, the production conducted animal reference shoots in England and California. "The best way to be faithful to animal anatomy is to gather as much reference footage as possible," noted Rhythm & Hues visual effects supervisor Bill Westenhofer, who oversaw the project with associate visual effects supervisor Raymond Chen. "We were fortunate to visit a cat rescue service in England that cares for endangered species and has a snow leopard population. We got a lot of great footage there, and photography of other cats, including bobcats, lynx, caracal and ocelot." Motion studies revealed animal behavior that Rhythm & Hues animation director Erik-Jan de Boer and a pool of 60 animators incorporated into keyframe dæmon performances. "It was similar to the way an artist might create a rendering in a traditional painted medium. They'd first copy life studies, and then do portrait sketches. We worked the same way with our animators. We gave them clips of footage, and they animated to those, studying the nuances."

To shoot dæmon scenes, puppeteer Tommy Luther voiced lines and manipulated stuffies with sticks to guide actor eye-lines. For tactile creature interactions, actors wielded greenscreen beanbag forms approximating the weight and shape of dæmons. Storyboards, however, did not always predict exact dæmon placement, with blocking often determined on set and creatures glimpsed on the periphery of frame. "We knew there were going to be dæmon shots with dæmon contacts that we would create in postproduction," commented Westenhofer. "The vast majority did not. To budget for that, I gave every shot that potentially had a dæmon contact an average cost and budgeted from there. That way, we were able to be creative with creature compositions."

Lyra's dæmon, Pantalaimon, was the most heavily featured animated creature in the film, able to transform at will — from ferret, to mouse, to wildcat, to bird, to moth, each animal representing a child's shifting moods through fleeting transformations. "Chris and I agreed transformations should be brief," said Mike Fink. "If we took too much time doing morphs, it was going to look like Willow; and I didn't think audiences would think that was interesting, as we've been seeing that effect now



Performers used weighted greenscreen forms to shoot dæmon interactions. For Lyra hugging Pan in his wildcat configuration, Rhythm & Hues rotoscoped the actress' hands and animated fur simulations to realistically compress in the girl's embrace.

for 15 years! We used very quick, simple transitions in 2D, blending briefly from one shape to another — which worked best if the animal was in motion.”

Dæmon transformations averaged between six to eight frames using 2D deformations of 3D models, choreographed to the character’s momentum and the emotional context of the scene. “If Pan went on the offensive, or needed to protect himself,” Erik-Jan de Boer explained, “he would change into a shape that was more suitable to the situation. We kept the transformations short; but even in a few frames, we used intelligent choices — would the head go first, or would the wings come out first? They were very fluid, organic transformations.”

Creatures of a much more imposing scale appear in North Pole scenes where Lyra seeks the assistance of Iorek Byrnison (voiced by Ian McKellen), a disenfranchised armored polar bear — a ‘panserbjørne’ — generated digitally at Framestore CFC. To film sequences featuring the hulking bear, the production cast Nonso Anozie, a British-born, Shakespearean-trained actor of Nigerian descent, whose six-foot-six-inch frame and resonant vocal range were a great asset in creating the illusion of the talking animal on set.

The visual effects team employed a variety of polar bear rigs to complement Anozie’s performance. “Iorek was 11 feet tall when he stood upright,” explained Mike Fink. “When he was on all fours, he was about five and a half feet tall. Nonso wore a white jumpsuit, and, because a polar bear’s neck and nose are quite long, he would guide Dakota’s eye-line by bending forward at the waist, with his head dipped flat. He’d take one arm and stick it out forward so his fist was where Iorek’s nose should be. Dakota spoke to the hand.”

Framestore CFC filmed reference to guide lighting and composition of bear scenes using a wheeled bear prop and a custom-made inflatable polar bear furnished by property master Barry Gibbs. “We had two poses of inflate-o-bear,” recalled Framestore CFC visual effects supervisor Ben Morris. “One was on all



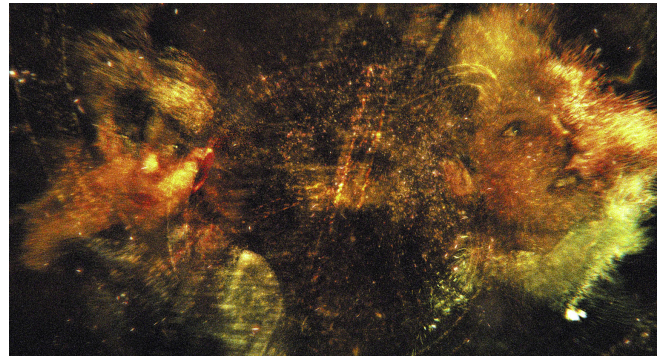
Pan, in ferret mode, adopts an inquisitive attitude as Lyra manipulates an alethiometer — a mechanical device that the girl uses to navigate her adventure. Rhythm & Hues generated seven animal forms representing Pan, who transforms at will as befits his mood and circumstances. Each Pan iteration retained a sapphire blue eye color, similar to Lyra’s, and characteristic brown and white markings rendered with an anisotropic shimmer representing the dæmon’s metaphysical nature. Motion studies of ferrets balancing on their hind legs suggested a trait that animators emulated in keyframe performances.



Pan, as a mouse, timidly approaches the alethiometer.

fours, and the other was a standing version. We could pack them up into a small bag, run out on set, plug them in and they would inflate in 30 seconds into a full-sized proxy bear. They were a fantastic help for the actors and crew to get a physical sense of a giant bear on set.”

For scenes with Lyra riding on Iorek’s back, Framestore CFC collaborated with special effects supervisor Trevor Wood and motion control specialist Ian Menzies to engineer a polar bear motion base. “We modified the seven-axis ‘M-Rig’ that we had used on *Dinotopia* and the *Harry Potter* films,” explained Morris. “It was quite an overhaul, with specialized components all based around a bear’s anatomy. Ian Menzies helped design the mechanisms and electronics. Trevor Wood machined and built the designs that Ian prepared. We ended up with a 12-axis motion-controlled rig that weighed about two and a half tons.” To create interactive bear parts for the motion base, effects technicians laser-milled a bear-shaped form, then sliced the form into shoulder sections, flanks and rump affixed to actuators. “A bucking actuator gave the bear up/down, rump and shoulder motion, and arm swing. Our M-Rig technical directors, Patrick Lowry and Andy Hayes, pre-programmed moves from animation that animation supervisor Dadi Einarsson and his team created in preproduction. We exported that information into the rig and the Mark Roberts Cyclops motion control camera. It took the M-Rig to another level in subtlety between animation and rider.”



As Lyra becomes adept at reading the alethiometer, communing with the device to guide her mission to the North Pole, the camera enters a magical realm inside the machine. Barry Gibbs’ team created a number of mechanical props that represented the alethiometer on set. During postproduction, New Line requested enhancements to reinforce Lyra’s bond with the alethiometer. Mike Fink and Susan MacLeod assigned the duties to Digital Domain, which introduced glows on the casing and enhanced the bezel. For interior views, diving through the gears, Digital Domain modeled clockwork mechanisms and volumetric effects, with Dust-like nebulae and glimpses of portentous imagery.

Lyra’s adventure begins in relative tranquility in Oxford, where Pan speaks to her beside a riverbank, flitting from wildcat form into a swooping sparrow before settling back into a ferret. Tommy Luther voiced Pan’s lines on location with Dakota Richards in England. Rhythm & Hues animated Pan through his transformations and rendered the dæmon with a subtle shimmer, hinting at the creature’s metaphysical nature. “We tried to find a look that conveyed that dæmons were something more than animals,” explained Bill Westenhofer. “We tried making them transparent, we tried different filters, but in the end it didn’t feel satisfying for all the effort we were putting into the characters; and there was nothing in the book that suggested dæmons were anything other than real creatures. We settled on a very subtle rainbowing effect along dæmon bodies, although they were solid and reacted to light in a real way.” Compositors controlled dæmon shimmer using chromatic maps that reacted to specular highlights, reflecting key-lights in scenes, seen most prominently in the beginning of the film in bright outdoor scenes and indoor scenes with strong light sources.

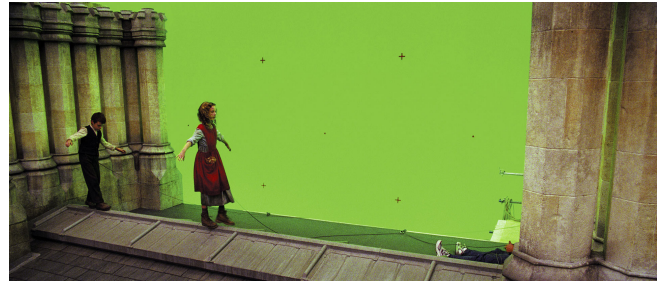
The production kept dæmon creature interactions to a minimum on set, relying on Rhythm & Hues technical animation lead Jen Bahan to create illusions of interactions digitally in the frame. “One of our trickiest interactions was for Pan pushing through Lyra’s hair,” noted Westenhofer. “We used a

combination of mapping Dakota's hair onto tubes that we could then deform, and layered 3D hair over that. Another integration that worked very well was where Pan is a ferret and he walks across a bed where Lyra is sitting. We modeled a bedspread shape to fit the surface of the bed. Our technical animators deformed that surface for each of Pan's footsteps. We mapped the original photography onto that and added shading so the bed appeared to move with the deformations."

Inside Jordan College, Lyra and Pan spy on Lord Asriel who arrives to give a demonstration of his latest discoveries. Barry Gibbs' team produced a light-emitting prop to represent Asriel's pictogram — a holographic projector that displays dimensional moving imagery of an explorer, Thorold (John Bett), beneath an Arctic sky filled with magical phenomena. Rainmaker composited pictogram imagery into the scene using elements generated at Rhythm & Hues. "We used our in-house fluid simulation system, Ahab, to create an aurora borealis effect we projected onto ribbon geometry," said Bill Westenhofer. "We used a particle system to create little wisps of light that ran back and forth through the aurora and applied procedural 'noise' to get them to flow, with a lot of activity in the center and then thinner, more ethereal veils off to the side."

The aurora contains glimpses of a mysterious city, visible within the colored lights, which Asriel believes to be the gateway to another world. Robert Stromberg generated the city as a digital matte painting, which Rainmaker blended into the environment with a greenscreen plate shot at Shepperton. "The plate consisted of Thorold and his black Labrador dæmon," said Rainmaker visual effects supervisor Paddy Eason. "We generated a starfield background, with the aurora and a hint of the city in the sky. We added scenic textures of distant mountains, clouds and ice, ran the footage in a loop and layered it like slices through a multiplane image." Rainmaker also generated gaseous, sparkling particles streaming from the sky representing a supernatural celestial phenomenon known as 'Dust.' "We used Side Effects Houdini particle animation to create Dust coming down from the heavens, with an implication that Dust is associated with the aurora. It emerged from the aurora, streamed down to earth, passed through the dog and into Thorold's chest in a big 'S' shape."

Accompanied by their dæmons, Lyra and her friend Roger (Ben Walker) retreat to a Jordan College rooftop to look out over their hometown. Cinesite initiated development of Lyra's Oxford cityscape



Lyra and her friend Roger (Ben Walker) pass the time of day on a Jordan College rooftop, overlooking their hometown of Oxford. To safely film performers and depict the grounds of the fictional college and the subtly altered parallel universe vista below, Chris Weitz filmed the scene with the young actors on a partial greenscreen set at Shepperton, with the camera mounted on a Technocrane. The camera move was based on photography and surveys that Cinesite conducted on location in Oxford, shooting high dynamic range image tiles at golden hour.



Cinesite used location tiles and textures to generate a digital matte painting vista of 3D and 2D buildings. Digital Backlot then tracked production plates in 3D and produced a multi-layered matte painting positioned behind the production photography. Rhythm & Hues animated Pan as a feline and Roger's dæmon in canine form, which were tracked to plate geometry and integrated onto the rooftop through the camera move. Characters, production plate and environment were then color-timed to give the scene a golden-hour look.

as a digital matte painting based on location photography. To survey the location, Cinesite shot high dynamic range plates of Oxford at the golden hour, capturing 360-degree tiles from a 50-foot crane. Digital matte painting supervisor David Early then used location tiles and textures to generate a 9K-resolution vista of 2D and 3D buildings. For Lyra's and Roger's rooftop scene, the actors performed on a partial rooftop set backed by greenscreen, filmed from a Technocrane. Digital Backlot lead compositor Paul Graff then tracked footage to derive a 3D camera move, and matte painter Dylan Cole produced a multi-layered matte painting that compositor Steve Messing nestled behind the set. Rhythm & Hues then added Lyra's and Roger's dæmon characters.

Later, on the backstreets of Oxford, Roger is kidnapped after encountering Mrs. Coulter's golden monkey — a conniving dæmon with a lustrous pelt. "The golden monkey was an amalgam of three or four monkeys of radically different scales," stated Mike Fink. "We looked very closely at a breed called a tamarin, which is a very small monkey, with gold, orange, black and dark brown fur, with huge manes and ugly faces. It was valuable reference, because our golden monkey didn't talk; so everything we knew about it had to come from how it behaved."

Neal Scanlan's team produced a golden monkey maquette with sculpted fur. Rhythm & Hues used scans as guidelines for body shape and details of the face and hands, then applied a complex fur groom. "The golden monkey fur was harder to create than Aslan's mane in *The Lion, the Witch and the Wardrobe*," said Bill Westenhofer. "It was a huge challenge because the hair on the head was quite long, but it was light for its mass, so it was not a big flowing simulation. When he tossed his head, there were very complicated friction forces between hairs that we couldn't simulate." To solve the hair behavior, the technical animation team used hair collisions combined with shot-by-shot tweaking and a technique known as a 'hairbag.' "We dropped a cloth shape from the monkey's head down onto his shoulders, stuck parts of the hair to that, and added dynamics. If he did a faster motion, the fur could break free and bounce back."

Cinesite generated 14 dæmons for a Jordan College scene in which a crowd of academics gathers in a library. "We had at least eight or nine dæmons in each shot," stated Cinesite visual effects supervisor Sue Rowe. "The Master of Jordan had a very beautiful raven dæmon. We had a raccoon sitting on another lap, a praying mantis, a spaniel, a rat, a black panther and, my personal favorite, a chameleon. Creatures like the rat and the praying mantis made up the 'baddies,' and we color-treated them with an evil dæmon look. The more lovable-looking characters we gave warmer shimmering tones similar to Pan." Adult dæmons, incapable of transformation, were modeled proportionally life-sized and true to nature, albeit with eyes colored like their owners and actions attentive to human conversation. Cinesite modeling supervisor Stephane Paris initiated dæmon designs by sculpting clay maquettes, and then modeled characters in Mudbox. Creature lead Ivor Middleton oversaw creature rigging, fur and feathers.

The Master (Jack Shepherd) later presents Lyra with a device resembling an oversized gold pocket watch that has a dial containing 36 tiny arcane symbols. Known as an 'alethiometer' — literally 'truth meter' — the gadget is a crucial tool that Lyra uses to navigate her adventure, interpreting her innermost



thoughts and queries. Barry Gibbs' team built four versions of the prop. "The props were about four inches in diameter," said Mike Fink. "Actors could adjust three pointers to select symbols on the porcelain ring around the perimeter of the dial. We had unmechanized alethiometers, not designed for closeups, that we could throw across the stage. The hero alethiometer could be seen close up and had a clockwork gearbox inside. When the operator turned little knurled knobs on the edge, they could set the pointers. We also had a version that Barry hooked up to a portable Kuper motion control system. We could pre-program where the needles moved and stopped on the symbols."

During postproduction, the studio called for elaborations on alethiometer scenes recalling a visual effects concept that Anand Tucker had explored to visualize the bond that Lyra develops with the device. "We wanted to show how Lyra could see things that other people couldn't see when she operated the alethiometer," Fink explained. "We had just started to talk about that when Anand left the show. When Chris came on board, the budget was high so we had to start cutting. We decided it was going to be enough for Lyra to carry around this beautifully wrought instrument; we'd know from the sound and the look on her face what was happening, without visual effects." To cater to the studio's request for more connection between Lyra and the alethiometer, and with only 12 weeks remaining on the postproduction schedule, Fink mooted an approach to augment the alethiometer's magical nature. "I suggested digital color correction and glows on the outside of the alethiometer case, and then enhancements on the insides when Lyra was making her readings. The studio said, 'Go for it!' Even with the short schedule, I was delighted to be doing it. I always thought it needed it."

Fink and MacLeod awarded the alethiometer work to Digital Domain, which rebuilt the prop's intricate mechanisms in 160 shots. "Our in-house art director, Claas Henke, came up with a design that Mike liked," said Digital Domain visual effects supervisor Bryan Grill. "We used textures and elements of a CG alethiometer that R&H built for their digital daemon work, and refined that for our closeup shots. We added glows behind the symbols, replaced the inside of the bezel, rebuilt the interior clockwork, and added layers of more gears and magical effects, which we see as the camera passed through the gears, entering a celestial/mechanical world where the gears had tiny glittery star patterns. Inside the alethiometer, we saw faces and pieces of the movie in a volumetric particulate environment reminiscent

Lyra prepares to leave Oxford with Mrs. Coulter (Nicole Kidman), an enigmatic benefactor who solicits the young girl's interest in an expedition to the North Pole, via London, on board a dirigible sky ferry. Chris Weitz filmed the scene in a quadrangle at Queen's College, in Oxford. Cinesite recorded lighting reference on location and generated Coulter's airship as a 3D model, detailed and textured with rivets and dirt, and rendered with environmental reflections and wind interactions to enhance the illusion of scale. Rhythm & Hues then animated daemons, including docile canines accompanying Jordan College serving staff.



Mrs. Coulter's sky ferry crosses the English countryside, making its way towards London. The production shot aerial plates for the scene.

Cinesite enhanced the sequence, integrating the digital sky ferry model into the plate with digital matte-painted elements. To help anchor the airship in the scene, matte artists introduced cumulus clouds into the sky and used articulated mattes to cast pools of light and shadow that crept across the landscape and created interactive lighting effects that slid across the dirigible's surface.

of Dust effects seen elsewhere in the film.” Digital Domain rendered internal machinery in RenderMan, added pulsing Houdini ‘tracer’ particles, and used its volumetric renderer, Storm, for internal nebulae. Compositing supervisor Joe Farrell then incorporated elements into alethiometer shots.

Lyra leaves Oxford with Mrs. Coulter on board a sky ferry — an ornate dirigible decked out in the livery of the Magisterium ecclesiastical governing authority. The production filmed the sky ferry embarkation in a quadrangle at Queen’s College in Oxford University. Cinesite recorded lighting reference using a high dynamic range reference cube, created by Rhythm & Hues, which used six lenses to shoot an instant 360-degree sphere of images. Cinesite CG supervisor Thrain Shadbolt generated the airship as a 3D model that incorporated environment reflections in its surfaces. “The sky ferry was a huge 147-foot-long, red-and-gold object,” remarked Sue Rowe. “In order to make that look as real as possible, we rendered it to reflect the environment and added a lot of details to give it scale, like dirt and rivets and wind affecting the skin. We made the tail fin look like it was made out of beaten gold, added a digital driver in the gondola and put Mike Fink’s face on him.”

The sky ferry crosses the English countryside to London in a sequence achieved with an aerial background plate, Matte World Digital enhancements, and Cinesite’s sky ferry geometry. “Cinesite developed assets that we added to,” stated Matte World Digital lead matte artist Chris Evans. “We developed the look of the sequence with cloud shadows and pools of sunlight dappling the landscape, and an armada of cumulus clouds moving along as the blimp was moving in and out of shadows.”

Angles of the sky ferry over London reveal the geography of the city, which Cinesite extrapolated from the production plates. “Mike was very keen on grounding everything in reality,” said Sue Rowe. “I had three days of shooting London from a helicopter using a Genesis camera to capture the city in the right atmosphere. London weather can change from glum to beautiful in no time at all, so we shot a lot of reference to pin down the time of day and make sure that was carried through the shot.”

Cinesite developed the digital environment, with David Early’s matte painters working with the 3D environment team to develop geometry and assets for panoramic views of the city and the River Thames. Matte World Digital artists Darin Hilton, Daniel Salvin and Jon Green then created London vistas with digital water, boats on the river, digital

street traffic, additional pedestrians, flapping flags, a distant train and air traffic. “We started with the foundation of the Cinesite buildings,” said Matte World Digital president Craig Barron. “We then added real-world elements, including the famous Swiss Re ‘Gherkin’ tower, rendered in more of a golden color, and real elements of clouds to give the shots a foundation in reality.” Matte World



The sky ferry advances on the Magisterium, seat of power of the ecclesiastical authority. The production shot Panavision Genesis aerial plates over London for the sequence. Cinesite used the high definition footage and still photo scenic textures to develop city elements. Robert Stromberg’s team at Digital Backlot then produced conceptual sketches of the Magisterium building, and Matte Word Digital developed vistas to completion for aerial views approaching the soaring structure. Artists built a 3D model of the tower using reference of London’s Kew Gardens and the Champs de Mars in Paris, and integrated elements of the Marin County Civic Center.

Digital also incorporated Cinesite city geometry, photographic textures and production plates for shots of the sky ferry slowly moving into foreground, revealing Lyra and Mrs. Coulter seated behind a nose-cone observation window, and composited Rhythm & Hues' dæmons in behind reflections in the window.

Robert Stromberg and Matte World Digital contributed to shots of the sky ferry arriving at the Magisterium's palace, filmed at the Old Royal Naval College in Greenwich. Digital Backlot compositor Paul Graff enhanced ground-level Magisterium views with soaring crystal architecture. Matte World Digital generated aerial shots. "Robert Stromberg established the structure of the main tower," explained Chris Evans. "We handled angles looking down from the blimp. We defined the ground plain and built a 3D model to create a tower that was about 800 feet tall." Matte World Digital artists Louis Hernandez and Morgan Trotter referenced London's Kew Gardens and the Champs de Mars in Paris, adding avenues of lawns leading up to the main tower and live-action elements of fountains that Craig Barron filmed at the Marin County Civic Center.



Mrs. Coulter's dæmon, a conniving simian known only as the 'golden monkey,' was based on nature reference of several different monkey species, with facial features inspired by a tamarin. Rhythm & Hues animated the creature with a lustrous pelt that required a complex fur groom to depict friction forces between hairs.

In London, Lyra flees Mrs. Coulter and runs into some travelers, known as ‘gyptians,’ who are on a quest to rescue kidnapped children enslaved by the Magisterium in the North Pole. For scenes establishing the gyptian sailing ship, the Nooderlicht, the production filmed a full-scale barge in the Thames estuary, and for scenes on deck built a center section of the ship as a greenscreen set at Shepperton. Cinesite augmented the shots. “We shot Genesis helicopter plates with the barge in the Wash estuary on the southeast coast of England,” explained Sue Rowe. “The barge was a similar size to the Nooderlicht — 140 feet long — and we shot it sailing away from camera as our helicopter hovered above. I shot orthographic views of other boats, capturing their wake. We took those elements into 3D and projected the water surface onto geometry, tracked a 3D camera move from the barge plate, did sea extensions using Houdini, and layered our CG Nooderlicht over the top.”

Dennis Gassner designed the Nooderlicht as an amalgam of paddle wheeler, sailboat and steamship with a funnel. In wide shots, Cinesite generated the vessel as a complete digital construct, with SyFlex cloth-simulation sails, Houdini simulations of paddles churning water, and motion capture characters representing gyptians on deck and in the rigging. For set extensions on deck, Cinesite used scans of the partial Nooderlicht set as basis for texturing, then rendered the ship’s timbers in nickel-colored wood tones.

On board the Nooderlicht, a pair of robotic ‘spyflies’ sent by Mrs. Coulter swoop out of the sky to surprise Lyra and Pan. Barry Gibbs’ team built two mechanical props to represent spyflies in scenes where Nicole Kidman released the drones to seek out the gyptian fleet. “The spyfly props each had their own designs and personalities,” noted Mike Fink. “Barry built a box to contain them, where one could be actuated by wires from underneath and made to flutter its wings and spring on its legs.” Rhythm & Hues enhanced the spyfly props, adding small green glowing thoraxes, and animated the creatures to buzz and flit about like angry hornets.

Meanwhile, further north — in a scene expanded from the book — Samoyed soldiers and their wolf dæmons capture Lord Asriel. For the Arctic action sequence, Fink and MacLeod brought in visual effects supervisor Steve Begg in postproduction to accompany the shoot, directed by stunt coordinator Vic Armstrong. Over a three-week period, the team shot aerial Genesis plates of the Swiss Alps and filmed mountaintop action of Asriel and his snow leopard, Stelmaria, fighting Samoyeds and wolf dæmons. “We didn’t have storyboards, so action was ad-libbed,” noted Steve Begg. “We had minimal physical effects, apart from bullet hits. We shot ‘stuffy’ animals as reference



Pan, in wildcat mode, wards off one of two robotic ‘spyflies’ that Mrs. Coulter dispatches to follow Lyra after the girl escapes from London. Barry Gibbs’ team built spyfly props for Kidman to manipulate in closeups. For more mobile and airborne scenes, Rhythm & Hues created spyflies digitally.

for Rhythm & Hues and HDRI passes. It was a wild shoot. At one point, we were hit by semi-hurricane winds and our stuffy snow leopard got blown into a chasm. Luckily it was attached to a rope, so we pulled it out again, but it was a ferocious environment. Beautiful, but constantly changing.”

Rhythm & Hues integrated dæmons, displaying the grace and power of Asriel’s snow leopard. “We looked for cues to sell the weight of the animal,” said Erik-Jan de Boer. “We used a lot of paw compressions, toe splays and elbow jiggle as Stelmara placed her feet. We did a lot of heavy scapula work and swung her belly to create the feeling of mass and internal organs. On top of that, we added skin harmonics and dynamic skin wiggle to our keyframe motion. Felines have very slinky head motion but, within that sleekness, a lot of smaller-frequency motions sold the weight.” Jen Bahan oversaw fur interactions, wind effects and instancing of tiny clumps of geometry to represent snow sticking to dæmon fur. Lead effects technical directors Nathan Ortiz and Eric Horton oversaw the creation of dæmon footprints in the snow, snow flurries, and clumps of snow kicked up by moving dæmons.

Gyptians arrive with Lyra at Trollesund, a Lapland port on their way to the North Pole. The production shot aerial plates for the Nooderlicht approaching and traveling through fjords off the coast of Norway, and shot building textures in the Norwegian town of Bergen. Dennis Gassner built sets at Shepperton for closer views, which the filmmakers combined with location work in London filmed at Chatham Docks. Cinesite expanded the environment. “About 30 percent of the foreground section of the plates shot at Chatham was real,” commented Sue Rowe. “We topped up the rest of the buildings, and created sky and mountains with plates that Mike Fink had shot in Norway. We also had a shot of Mrs. Coulter’s sky ferry entering fjords that Mike shot in that area. The majority of our shots of Trollesund with mountains in the distance used 3D buildings with matte-painted projection.”

Disembarking at Trollesund, Lyra meets Iorek, the panserbjørne, and converses with the bear as he dines at Einarsson’s Bar. The intimidating creature — scarred and bellicose — was the product of



Lyra arrives in Trollesund, a trading port where she meets new allies in her journey north. In preproduction, Mike Fink and associate visual effects supervisor Eric Pascarelli shot digital still photography and helicopter motion picture footage at the Arctic and Scandinavian locations, gathering scenic winter textures of landscapes for visual effects vendors to use in reconstructing frozen north environments. Wide shots approaching Trollesund used aerial views of Norwegian fjords and the town of Bergen. For ground level exteriors, production designer Dennis Gassner dressed parts of London’s Chatham Docks as Trollesund, with plans for digital enhancements.



Cinesite expanded Trollesund production plates by adding buildings beyond the Chatham Docks to extend the town by 70 percent. Artists constructed Trollesund architecture in a combination of Thai and Nordic architectural styles and assembled buildings digitally by using texture reference of architecture shot in Bergen, projected onto 3D geometry. Beyond the background buildings, Cinesite built mountains and arctic skies using scenic still textures, then tracked and layered buildings and mountains behind foreground plates to create the illusions of parallax during camera moves.

Neal Scanlan Studio maquette work and a long development at Framestore CFC headed by CG supervisor Andy Kind and creature supervisor Matt Hughes. “We worked directly in CG with grooms and fur looks,” Ben Morris noted. “Iorek started off as a shaggy monster bear. That slowly got shaved back over a period of months and became what we termed the ‘princely bear,’ where he was cleaned and groomed. Several months later, he reverted to a shaggier bear — with dirt, grease and blood from eating a reindeer leg. There was a real development arc in his look, as well as his performance.”

Framestore CFC explored Iorek’s personality using nature reference and footage shot with a trained polar bear. “We tried to stay as close to real polar bear movement as possible,” said Dadi Einarsson. “Real polar bears tend not to run in a very heroic style, and our early tests weren’t heroic enough for Chris, so we stylized Iorek’s run a bit more towards a traditional quadruped gallop.” To guide the tone of Iorek’s performance, Weitz referred Framestore CFC to Akira Kurosawa’s favorite leading actor, Toshiro Mifune. “We kept Iorek stoic and underplayed, with a furrowed brow. We had pretty good control over his lips, snarl and nose motion — but we used those sparingly. Bears have a very long snout, and broad ‘oo’ shapes did not look convincing, so we avoided moving the corners of the mouth and instead pursed the back of the lips and pushed the front of his lips out a bit more. We got a lot of character from moving the snout around, which pivoted from halfway down the nose. We also noticed bears blink with a full facial blink, as opposed to just using their eyelids like a human. We worked all those features into the way he talked.”

A large part of Iorek’s look was dependent on his fur, which not only moved dynamically with the character’s keyframe animation, but also absorbed environmental colorations. “Polar bear fur is prismatic,” said Mike Fink. “The fur is actually yellow, the skin a dusty black; but each strand of fur is a tube, hollow in the middle, almost clearer than a fingernail, so it refracts color. That is incredibly difficult to replicate, for a couple of reasons. One, because the fur is refractive it picked up any color corrections we did to the environment. If we shifted the scene a little red, the bear became pink; if we shifted a little green, the bear became green. We had to pre-grade all our bear scenes to a very high complexity because if Peter Doyle, the digital colorist on the film, tried to manipulate the shots the bears would fall apart. It was a constant back and forth, taking shots to Peter, and bringing them back to Framestore CFC.”

“White fur on white snow is hard!” concurred Ben Morris. “We had to be extremely sensitive in grading. If we dropped values in a shot by four points, it suddenly revealed a multitude of colors reflected from the environment. Iorek was one of the hardest characters we have ever had to light.” To assist the fur rendering process, Framestore CFC digital effects supervisor and R&D lead Alex Rothwell rebuilt the studio’s fur pipeline. Using filter stack technology, artists layered clumping, scraggle, collisions, occlusion and other fur simulation properties. “We could add dirt, calculate correct shadows and contact with surfaces, and cull back fur on Iorek’s



Chris Weitz shot other scenes in and around Trollesund on soundstage sets and the backlot at Shepperton, including a confrontation between Lyra and Iorek Byrnison, an armored ‘panserbjørne’ polar bear. Actor Nonso Anozie, wearing a white jumpsuit, played Iorek on set to guide actor eyelines and character interactions. Framestore CFC

face with automatic levels of detail control. Some of these features are standard features for fur simulations, but we took them to a much higher level than we ever used before. Putting armor on top of that and then articulating that, with all the subtle shadowing and dynamics issues, it became even more difficult.”

filmed reference of a wheeled bear prop and an inflatable dummy on set, and then generated Iorek digitally, creating a powerful, yet understated keyframe-animated performance and a highly detailed fur simulation.

Animators used a ‘skinny’ bear proxy model to establish Iorek’s core performance. A ‘fat’ bear model emulated Iorek’s furred silhouette and a tertiary rig was used to fit armor over the furred form. Armor was rendered as a brownish pig iron with levels of iridescence, giving the ‘sky iron’ metal an unearthly quality that fit the panserbjørne as a rough-hewn carapace. “The armor rode on the back of the animation,” Dadi Einarsson related. “Our creature technical directors then made certain the armor moved correctly, but it was always performance-led. We wanted to feel the weight of the armor; but Iorek had to be amazingly agile inside it, particularly when he was fighting.”

Iorek’s performance took a major turn in postproduction when New Line recast Ian McKellen as the voice performer. “Our lead animator, Craig Bardsley, had been animating Iorek based on the vocal performance of Nonso Anozie,” said Einarsson. “Each line had informed gestures of Iorek’s head, and that affected his footsteps. We had pretty much finalized Iorek’s introduction when they told us, 12 weeks from delivery, that they were going to change the voice; so we had to re-do that whole sequence. In some scenes Sir Ian came fairly close to the previous performance, but in others he didn’t. That was a challenge.”

Lyra continues north with Iorek and the gyptians, traveling through environments filmed at Shepperton, enhanced by Framestore CFC digital environment supervisor Martin Macrae. “We used photographic elements in the distance and 2D texture projections,” explained Ben Morris. “The foreground, where characters were interacting with the terrain, was entirely CG. We created surfaces for them to walk over with simulations of snow powder blowing across and displacements of feet going into the snow using ‘churn’ particle simulations to kick up material from footprints. We then added finer-detail 2D elements. A lot of interactions required 3D interactions because they were easier to animate in a 300-frame shot than patching in elements.”

Gyptians camp beside a forest and are attacked by Samoyed soldiers. The production shot the Samoyed raid on a non-greenscreen soundstage set but later enhanced the environment significantly. “The idea had been to crowd the stage with trees and rocks to create a real environment using a painted backing,” explained Susan MacLeod. “Somewhere along the way, the trees got removed and it became rocks and tents and a painted cyclorama; and the results, unfortunately, looked like a painted cyclorama.” Rainmaker used scenic material of mountains to build a 270-degree digital environment around the camp. “We re-created the sky with a big dazzling



For scenes of Lyra riding on Iorek’s back, Framestore CFC generated the bear and its arctic environment digitally, using still photo elements and texture projections for

moon and replaced the background,” said Paddy Eason. “That required a lot of rotoscoping and tracking; and the air was full of hanging smoke, which we had to keep consistent from shot to shot. We divided the action into planes and stacked it up with distance haze in the composite. We did a bit of treatment on the ground to make the artificial snow look more fluffy, and added rock formations and yurts around the edge of set to tie it all together.”

distant scenery, and 2D elements and particle animation to create realistic bear and rider interaction. Framestore CFC collaborated with Trevor Wood’s special effects team and motion control specialist Ian Menzies to engineer a gimbal rig for Dakota Richards to ride. The motion controlled rig was capable of repeating anatomically correct bear motion based on keyframe animation created in preproduction, and interacted with motion control lighting cues on the greenscreen stage.

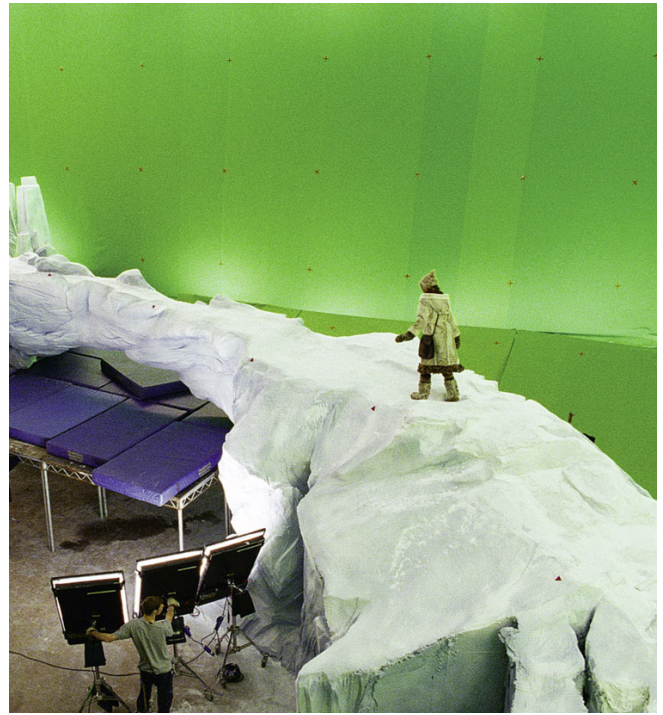
In a departure from the narrative order of the book, Samoyeds abduct Lyra and take her to the panserbjørne stronghold of Svalbard, an imposing frozen structure ruled by the bear king Ragnar Sturlusson (voiced by Ian McShane). The production filmed live-action elements representing Sturlusson’s palace on greenscreen sets at Shepperton. Framestore CFC added extensive digital extensions. “Mike brought back footage of some incredible rock formations from his Svalbard shoot,” remarked Ben Morris. “The landscape looked like Monument Valley, with giant rock stacks. Ragnar’s palace was located inside one of the stacks on an ice plain. Wide shots were digital matte paintings. For the ice plain, we created an entirely CG environment, rendering 3D geometry with snow shaders and procedural ice shaders to create light-scattering effects and refraction in the ice.”

Inside the palace throne room, Lyra confronts Ragnar Sturlusson, an even larger bear than Iorek. Chris Weitz shot the scene in a minimal greenscreen set comprised of a carpeted floor and throne dais, while puppeteer Tommy Luther performed Ragnar in full body prosthetics. “Tommy had extensions on his legs and arms,” noted Mike Fink. “He wore a backpack that extended up above his head with a lightweight shell representing a greenscreen bear skull on the top that was counterbalanced to stay level. If Tommy stood upright, the head stayed level at 11 and a half feet. When he dropped onto all fours, the head hinged down and maintained an eye-line with Dakota. Tommy was wonderful in that rig. He’d walk around acting like a bear, occupying the space that Ragnar occupied. It was tremendously useful for Dakota and the crew.”

Framestore CFC used shots of Luther in the Ragnar rig as production plates and digitally painted out portions of the rig not extracted from greenscreens. The digital character required a new creature build, proportionally more akin to a grizzly bear, which lead animator Philip Morris animated to define the panserbjørne king with aspirations above its animal nature. “Ragnar was a thug,” commented Dadi Einarsson. “Ian McShane’s voice performance had a lot of range — very dastardly and evil — which played into his look, with a great big head and beady eyes. Ragnar was deluded in his own grandeur, quite expressive in his face and demented. Prodded the wrong way, he became animalistic in a split second.”

Outside the palace, Framestore CFC generated crowds of up to 100 polar bear militia, sampling and interchanging Iorek and Ragnar bear models with varieties of detail, populated around the ice using Framestore CFC’s in-house multiple character animation tool, Choreographer. The bears surround Ragnar and Iorek, who battle for leadership of the panserbjørne in a 100-shot climactic duel sequence handled by fight sequence lead animator Pablo Grillo and CG supervisor Laurent Hugueniot.

To choreograph the bear fight, the filmmakers used a tabletop foamcore mockup of the fight arena, cutout figures and a lipstick video camera, and improvised from storyboards. The lipstick camera sessions saved Framestore CFC weeks of digital previsualizations and paid dividends as the sequence developed. “It was such a fluid and dynamic way of working,” said Ben Morris, “we could throw ideas around very quickly and then, working with Mike Fink, solidify shots into edits that we used on set for the palace sequence, inside and out. We adapted some shots, but many of the cuts in the final film are pretty strongly based on the animatics. When you’re responsible for 15 to 20 minutes of a feature film, which is almost entirely digital, it’s hugely satisfying to be able to work so closely with the live-action production team.”



Lyra becomes separated from Iorek at a precarious ice bridge, which breaks apart underfoot. To capture elements of Lyra venturing out over the crevasse, the production filmed Dakota Richards crossing a partial set piece against greenscreen on a Shepperton soundstage. Closeups were then reshot with Richards walking across a greenscreen plank.



Digital Domain re-created the ice bridge digitally, introducing translucency and fracturing effects. Artists generated the crevasse using matte painting textures projected onto 3D geometry, and used rigid body dynamics to create effects of ice fragments splintering and tumbling into the abyss.

Fight action featured graphic and powerful compositions with 360-degree camera moves circling the arena and low closeups capturing engagements of the bears. The animation scaled back gore described in Pullman's book to focus on the emotional context of the fight — Iorek the stoic underdog versus Ragnar the gaudy king in polished plate armor and chain mail. "We didn't see limbs torn off," remarked Morris, "but it was pretty violent. Real bear fights consist of bursts of action lasting four or five seconds. We took a little artistic license with that and the intensity of engagements. But we did that to set up the dynamic of the fight and Iorek's peril before he finally turns on Ragnar and defeats him."

Iorek heads out into the wilderness with Lyra on his back. Lyra's ride across the snow featured an entirely digital environment of glacial valleys, snow and rock formations, combined with elements of Dakota Blue Richards riding the Iorek M-rig. "We only used a CG Lyra for half of one riding shot," Morris remarked. "It was a testament to the preproduction effort that we invested in the motion base. We sometimes had to undercrank Lyra elements, but most of the time they worked well because we'd been able to fine-tune the performance before we turned up on set." To film angles where Lyra rode Iorek from the far distance into dynamic closeup, the motion control team created an illusion of Iorek's movement by moving the camera past the stationary M-Rig. "The M-Rig was bolted to the floor, with about 70 feet of motion control rail next to it. We programmed the camera to sweep past the bear, creating the impression that the bear was coming from a long distance."

Framestore CFC compositing supervisor Ivan Moran fitted Lyra to the animated bear by creating a soft blend in the M-Rig's fur. "We didn't want to sit Dakota on a green bear because of all the shadowing and green spill on her legs," explained Mike Fink. "We thought we'd have a better job if we could have her interact with real fur and bring our CG fur up to it. Barry Gibbs found a real polar bear pelt — legally, which cost a fortune — and went through amazing lengths to prepare it. The pelt was not tanned and was very stiff; so Barry found an animal fur specialist in New York who transferred the fur to a stretchy substrate. Barry's guys draped that over the form. It was exquisite, and gave us great interactions."

Lyra and Iorek encounter a precarious ice bridge across a crevasse. Framestore CFC handled scenes of Iorek and Lyra leading up to the crevasse. Digital Domain generated the ice bridge. "We used an ice shader and digital painted textures to create the ice bridge," observed Bryan Grill. "That brought out any cracks and subtle subsurface effects in the ice under Lyra's feet. Our matte painting lead, Brenton Cottman, created painted textures for the crevasse and we projected those onto 3D



Lyra discovers Bolvangar, a remote research station used to house kidnapped children and their dæmons. The production filmed Bolvangar exteriors at Shepperton on a partial set that included a doorway on a snow plane surrounded by greenscreen. Cinesite then rendered Bolvangar structures digitally and generated surrounding scenery using high-definition digital scenic footage mapped onto 3D geometry. For a later scene, during a battle outside the building, Cinesite miniature effects supervisor José Granell oversaw construction of a portion of Bolvangar as a 'black box' miniature form used to shape a pyrotechnic element of the building bursting into flames.

geometry. CG supervisor Darren Hendler and effects lead Ryo Sakaguchi then used rigid body dynamics to create ice fragments breaking off.”

Separated from Iorek, Lyra arrives at Mrs. Coulter’s child internment camp at Bolvangar. The production filmed Bolvangar exteriors on a snow plain on Shepperton’s H-Stage, with a doorway into the compound surrounded by 360 degrees of greenscreen. Cinesite generated arctic scenery using Genesis footage mapped onto 3D geometry to create a 360-degree digital environment of snow-covered jagged peaks and ice, and rendered Bolvangar structures digitally. “Bolvangar was a beautiful building built of wrought iron and glass,” said Sue Rowe. “It was a bit art deco, a bit art nouveau, and very sinister, emitting green light. We built the building in 3D, with security towers and roving searchlights, and replaced a lot of the practical snow.”



During the battle at Bolvangar, Lee Scoresby (Sam Elliott), a Texan aeronaut, arrives to assist Lyra’s escape in a jury-rigged balloon. For closeup scenes on board the balloon, Trevor Wood’s team built a hydraulic motion-base rig that enabled the production to control motion of Scoresby’s balloon in real-time, with recordable motion for repeat takes, filmed against greenscreen. Cinesite then generated aerial environment extensions and upper portions of the aircraft, including CG rigging and four 3D spheres animated to represent Scoresby’s hot-air balloons.

Inside Bolvangar, Lyra and Pan are laid beneath a guillotine-like device used to sever a child from its dæmon. The filmmakers staged the scene with Dakota Richards beneath a wire cage containing a conducting filament, into which Rhythm & Hues placed a blade of light. “We had to come up with an effect that had a blade-like edge that looked like it was created from energy,” noted Bill Westenhofer. “We used our fluid simulation engine, Ahab, to create water patterns that had an internal structure with rippling waves passing through it. The leading edge had tiny white flames stacked up like a serrated knife blade, flowing and animating. The blade came down between the cage doors and, as it approached Lyra and Pan, we revealed energy connecting them, becoming agitated as they are about to be ‘intercised.’”

Strange, sparkling manifestations of Dust are also seen as gyptians invade Bolvangar and fierce fighting breaks out with many human and dæmon casualties. “There’s a statement in the story that Dust channels through a dæmon into its human,” remarked Westenhofer. “We took that literally and created an effect where if a dæmon dies they burst into a cloudy, dust-like pattern with stars twinkling within, somewhat like a nebula. We tried particle animation, but that was not interesting enough, so we did it as a fluid simulation. Whenever we animated a dæmon death, we applied Ahab to the dæmon’s motion and the Dust inherited the dæmon’s velocity with nice little eddies and vortices. We rendered fur textures to transform into a smoky color for a very brief instant, and then they burst into golden, starry embers.”

Five visual effects vendors supplied effects for the Bolvangar battle.

Cinesite initiated environments, including the film’s only miniature shoot — a ‘black box’ buck of the Bolvangar building designed to shape a pyrotechnic element. Cinesite miniature effects supervisor José Granell shot elements with Steve Begg on a night shoot on the Shepperton backlot,

producing fireballs that averaged 40 feet across, filmed with three cameras at 120 frames per second. Cinesite senior compositor Warwick Campbell and visual effects supervisor Matt Johnson then integrated flames into the CG building as fierce fighting breaks out between gyptians and Tartars and their dæmons. For about 50 ground-level shots on the battlefield, Digital Domain used Cinesite elements and 3D geometry, incorporated into Nuke, and created projections of pan-and-tile 3D environments for greenscreen shots.

Rhythm & Hues and Cinesite produced hordes of dæmons for the fight. Cinesite animated as many as 20 per shot in some scenes. Rhythm & Hues animated dæmons for 80 shots in the battle, using keyframe animation for the first 30 feet of foreground and Massive artificial intelligence crowd replication techniques beyond. “Massive needs a lot of labor up-front before it can start running crowd simulations,” noted Erik-Jan de Boer. “It’s relatively easy to populate Massive motion trees with bipeds or characters that can be motion captured. With quadrupeds, it’s more complicated. We created hundreds of additional motions to feed our Bolvangar Massive motion trees. That gave us great control for blocking, and gave the shots their richness.” Tippet Studio also added to the mêlée, using Rhythm & Hues’ wolf dæmon model to render four versions of the wolf, and populated scenes with up to 40 canines tangling with Iorek, who was animated at Framestore CFC.

Gyptians receive assistance during the Bolvangar battle from Serafina Pekkala (Eva Green), a witch queen with ties to the gyptian clan, who leads other witches that swoop from the sky on cloud pine branches, raining arrows on the Tartar army. Trevor Wood created a custom body pan for Green who performed closeup wire rig work in a diaphanous flowing costume filmed against greenscreen. Cinesite orchestrated additional wire-flown witches for wider shots on the Shepperton greenscreen stage. “Seventy percent of the witches were stunt performers on wires,” said Sue Rowe. “The second-unit director and I worked out a sequence of events for how we wanted to shoot the elements. We got them moving and rotating, and captured perspective changes in camera — the poor stunt girls were at it for four days! We layered them digitally across frame, and added CG arrows. We also used a cyberscan of Eva Green to make a 3D Serafina with SyFlex cloth simulation robes. We did a few face replacements of Eva and had as many as 20 3D witches in the distance flying behind our 2D witches.”

At the climax of the battle, another gyptian ally, Lee Scoresby (Sam Elliott), a Texan aeronaut, arrives to rescue Lyra in a jury-rigged balloon. Trevor Wood’s physical effects team constructed a motion-base rig for Scoresby’s balloon that consisted of a motion controlled hydraulic gimbal, controlled in real-time by means of a waldo with recordable motion for repeated takes, photographed against greenscreen.

Cinesite then furnished aerial environment extensions and upper portions of the aircraft. “We hand-tracked shots in boujou, derived the 3D camera motion and added four balloons,” stated Rowe. “We had two large 3D spheres on top and two smaller on the bottom, animated in SyFlex. We added CG rigging with dynamic animation so that everything could move through a long dialogue between Scoresby and Serafina as they traveled over a sea of clouds. We generated clouds in Houdini using a custom Open Graphics Library renderer to render them efficiently, and made them look moonlit and beautiful.”

While completing what amounted to 1,400 visual effects shots, the filmmakers made a decision in the final hours of postproduction to hold back the concluding chapters of Pullman's book for inclusion in subsequent sequels. "We were always thinking about the following two books," observed Mike Fink. "They came up in discussion every day. Of course, we had to focus on finishing this movie and hope that the others would take care of themselves, but we were always conscious of the new characters we'd be meeting in *The Subtle Knife* and their fates in *The Amber Spyglass*."

The filmmakers completed *The Golden Compass* with a tentative plan to film the two concluding stories back to back. "They've started writing *The Subtle Knife*, and I believe they want to start production as soon as possible," said Susan MacLeod. "Of course, everything is pending the financial success of the first movie. We don't know where they will shoot them yet, but they will need to get into the sequels pretty quickly based on the fact that Dakota is growing up!"

Beyond the technical challenge of the production, the adult tone of Pullman's books remained a focus on the film that set the project apart from many of its contemporaries in a marketplace crowded with fantasy franchises. "When I read the first book," concluded Mike Fink, "I only knew of *His Dark Materials* as a children's book. After my interview with Anand, I immediately went out and bought and read the other two. I was just stricken by the books. I was swept away by the first script I read. It was absolutely unshootable, but I thought if we'd just be able to realize ten percent of it, we'd have a great movie. We worked really hard to put the show together, and I think all of us are proud of what we have created. It was not just a children's movie."

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